THE JOURNAL OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

FEBRUARY · 1916 ·

SPRING MEETING, NEW ORLEANS, APRIL 11-14

TABLE OF CONTENTS

PAGE

PROCEEDINGS SECTION

Automatic Mechanical Control of Lathes and Screw Machines, L. D. Burlingame 103
DISCUSSION: C. M. Conradson, Ralph E. Flanders, Elmer H. Neff, Norman Marshall, H. K. Hathaway, the Author 109
Electric Operation and Automatic Electric Control for Machine Tools, L. C. Brooks 112
DISCUSSION: H. D. James, H. F. Stratton, C. D. Knight, H. K. Hathaway, H. J. Eberhardt, Ralph E. Flanders, Elmer H. Neff, the Author 117
Safety Code for the Use and Care of Abrasive Wheels 121
Operation of Parallel and Radial Axles of a Locomotive by a Single Set of Cylinders, Anatole Mallet 125
DISCUSSION: E. A. Averill, Carl J. Mellin, W. F. Kiesel, Jr., G. R. Henderson, W. E. Woodard, George L. Fowler, E. B. Katte, Roy V. Wright, C. D. Young, S. M. Vauclain, F. J. Cole, W. F. M. Goss, the Author 129
Foundations, Charles T. Main 135
DISCUSSION: M. M. Upson, Charles H. Bigelow, A. G. Monks, Sanford E. Thompson, F. A. Waldron 137

ANNUAL MEETING DISCUSSION

Design of Fire Tube Boilers and Steam Drums, F. W. Dean 140
DISCUSSION: W. F. Kiesel, Jr., Thomas E. Durban, the Author
The Heat Insulating Properties of Commercial Steam Pipe Coverings, L. B. McMillan 140
DISCUSSION: Leonard Waldo, F. M. Farmer, Herbert N. Dawes, Arthur M. Greene, Jr., L. R. Ingersoll, the Author
Circulation in Horizontal Water Tube Boilers, Paul A. Bancel 142
DISCUSSION: George L. Fowler, William Kent, John C. Parker, Arthur M. Greene, Jr., Ambrose B. Dean, A. A. Cary, the Author
Performance and Design of High Vacuum Surface Condensers, Geo. H. Gibson and Paul A. Bancel 144
DISCUSSION: Leo Loeb, R. N. Ehrhart, George H. Gibson, Paul A. Bancel
Higher Steam Pressures, Robert Cramer 146
DISCUSSION: William Kent, R. J. S. Pigott, G. I. Rockwood, R. H. Rice, Walter N. Polakov, Carl C. Thomas, D. S. Jacobus, the Author
Proportioning Chimneys on a Gas Basis, A. L. Menzin 148
DISCUSSION: A. G. Christie
Unique Hydraulic Power Plant at the Henry Ford Farms, Mark A. Replogle 149
DISCUSSION: Clemens Herschel, R. L. Daugherty, the Author
Oil Engine Vaporizer Proportions, Louis Illmer 151
DISCUSSION: Wm. T. Price, the Author

CORRESPONDENCE FROM MEMBERS OF THE SOCIETY 153

SOCIETY AFFAIRS

Spring Meeting 155
Annual Meeting 155
Report of Power Test Committee 155
Comments on Annual Report of the Council 156
Council Notes 157
Special Council Meeting 157
The Library Board 158
Pan-American Scientific Congress 159
Engineer Reserve Corps 159
The Boiler Code in Technical Schools 160
Members for Aviation Service 160
Notes 160
Applications for Membership 160
Personals 162
Necrology 163
Meetings 164
Student Branches 165
Employment Bulletin 167
Accessions to the Library 170
Officers and Committees 174

REVIEW SECTION

Engineering Survey 179

PROFESSIONAL AND EDUCATIONAL DIRECTORY

Consulting Engineers 2
Engineering Colleges 4

ADVERTISING SECTION

Display Advertisements 8
Classified List of Mechanical Equipment 46
Alphabetical List of Advertisers 60

PUBLISHED MONTHLY BY

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

29 West Thirty-ninth Street, New York

PRICE 35 CENTS A COPY, $3.00 A YEAR; TO MEMBERS AND AFFILIATES, 25 CENTS A COPY, $2.00 A YEAR. POSTAGE TO CANADA, 50 CENTS ADDITIONAL; TO FOREIGN COUNTRIES, $1.00 ADDITIONAL

C55. The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions.

Entered as second-class matter, January 4, 1911, at the Post Office, New York, N. Y., under the act of March 3, 1879

Leading Features in this Issue

In the Technical Section are published the two Machine Tool papers, the Abrasive Wheel code, one of the Locomotive papers, and the Foundations paper, presented at the Annual Meeting, with discussion; together with the discussion of the eight Annual Meeting papers published in the last issue. The authors of the new papers published and their topics are:

Anatole Mallet, honorary member, Paris, France, inventor of Mallet locomotive. Summarizes authoritatively inventions for driving radial locomotive trucks.

L. D. Burlingame, industrial superintendent, Brown & Sharpe Mfg. Co., Providence, R. I Reviews automatic mechanical control of machine tools.

Louis C. Brooks, electrical engineer, Industrial Control Department, General Electric Co. Discusses electric control of machine tools.

Charles T. Main, engineer, Boston. Sets forth the requirements for foundations for industrial buildings.

In the Society Affairs Section appear various items of interest regarding present and coming activities. This Section includes Council Notes, Pan-American Congress, The Library Board, Power Test Report, Employment Bulletin, Spring Meeting, etc.

New Applications for membership received in January, 1916, are posted on page 1€0.
Total membership of the Society, January 25, 1916 6,960

THE SPRING MEETING

NEW ORLEANS, APRIL 11-14, 1916

THE Spring Meeting this year is to be typically a Southern meeting, with Southern hospitality, Southern engineering papers and an opportunity for those who do not often visit that part of the country to become more familiar with engineering practice in the South.

The meeting is to be held in April, which is one of the most delightful months of the year in New Orleans, and members have their choice in going or returning of a five-day sail on one of the finest coast-wise steamers, or of going by rail, with stops possibly at Cincinnati and Birmingham, where greetings will gladly be extended by the local members.

Where a considerable number of members can travel together in a party for two or three days or more, as in the present case, the opportunities are unusual for extending acquaintance in the fraternity of the membership and for general good fellowship. *Let everyone who can do so plan to attend!* A good time is in store for all who go to the New Orleans meeting.

TRANSPORTATION RATES

Rates to New Orleans are $75 for round trip fare from New York. This includes steamship both ways, or railroad going and steamship returning, or vice versa, and includes meals and berth on steamer. This provides also for those who start from an inland city, as Cincinnati, going by rail and returning by steamer to New York and thence by rail to Cincinnati. Round trip by rail, New York to New Orleans, $56.30. Pullman fares, New York to New Orleans, $8 lower berth; $6.40 upper berth. Full information about transportation will be sent to members by circular in due course.

PAPERS

Papers for the Spring Meeting should be sent to the office of the Secretary at once. On account of the time required for all the members of the Committee on Meetings to read the papers submitted, and because of the insistence of the membership that the accepted papers be printed and distributed well in advance of the meeting, any papers received later than February 10 are liable to be held over for a later meeting.

COMING MEETINGS OF THE SOCIETY

February 2, *Buffalo, N. Y.* Subject: Public Service, by Morris L. Cooke, Mem. Am. Soc. M. E., and Director of Public Works, in Philadelphia.

February 2, *St. Louis, Mo.* The subject of this meeting will be Certain Uses of Concrete.

February 3, *Philadelphia, Pa.* Subject: Developments of the Pumping Engine, by Prof. A. M. Greene, Jr., Mem. Am. Soc. M. E., Prof. Mech. Engrg. Dept., Rensselaer Polytechnic Institute, Troy, N. Y.

February 8, *Boston, Mass.* There will be a joint engineers' dinner held at the City Club of Boston. There will be several prominent speakers at the dinner whose names will be announced later. The dinner will be in charge of the Boston Section of the Am. Soc. M. E.

February 8, *New York.* Subject: Ways of Presenting Data for Executive Purposes, by T. Russell Robinson, Statistical Engineer, W. S. Barstow Co., Inc., N. Y.

February 15, *Worcester, Mass.* Subject: What are the Fleet Units of a Naval Attack, by Dr. Ira N. Hollis, Mem. Am. Soc. M. E., Pres. Worcester Poly. Inst., Worcester, Mass.

February 16, *St. Louis, Mo.* Subject: Military Engineering, by Major Willing of the U. S. Engineers.

March 17, *Chicago, Ill.* Subject: Development of the Crude Oil Engine, by S. B. Daugherty, Mem. Am. Soc. M. E., and Chief Engineer, Snow Steam Pump Works, Buffalo, N. Y.

April, New Haven, Conn. Date and details of this meeting will be announced later.

THE SPRING MEETING

April 11–14, *New Orleans, La.* Spring Meeting of The American Society of Mechanical Engineers. Headquarters, Hotel Grunewald.

ANNUAL MEETING PAPERS

THE 36th Annual Meeting of the Society held in New York, December 7-10, 1915, like the previous Annual Meeting, was characterized by professional sessions, of which there were seven, devoted to Power Plants, Machine Shops, Railroads, Textiles, Industrial Safety, and Miscellaneous. In the January issue were published the Presidential Address and eight papers including those given at the Power Plant Session. In this issue are presented in abstract the three papers contributed by the Sub-Committee on Machine Shop Practice, one of the papers contributed by the Sub-Committee on Railroads, the paper contributed by the Sub-Committee on Industrial Building, together with the discussion which followed. There is also published the discussion which was brought out by the professional papers appearing in the January number.

AUTOMATIC MECHANICAL CONTROL OF LATHES AND SCREW MACHINES

BY L. D. BURLINGAME, PROVIDENCE, R. I.

Member of the Society

IN a general way the term "automatic control" applies to the organization of a machine so that *all* operations required to complete the work are automatically performed, and the object is to have these operations so performed as not only to secure in large measure the advantages of hand work guided by human intelligence, but also to insure a uniformity and quantity of product beyond that which can be commercially obtained by hand work.

In determining whether the employment of automatically controlled machines is warranted, the vital question is whether the product is wanted in sufficiently large quantities and whether the design is sufficiently well established to justify the investment in such special machines.

It must be determined whether the added original cost and greater cost for repairs are justified when to this must also be added the more expensive tool equipment and longer time required for setting up. In considering the cost for repairs, the conditions to be borne in mind are the greater danger of a breakdown and the greater skill required to keep the machine in running condition.

The fact that in operating automatically controlled machines the human factor is less in evidence than is the case in hand operated machines, makes it possible generally to employ less skilful workmen without lowering the quality of the work. On the other hand, the use of automatically controlled machines increases the need of skilful supervision and of skilled men for their construction and repair.

The features most prominent and essential in the automatic control of machine tools can be classified as follows:

I Spindle drives

II Means for inserting and removing the work

III Feeding mechanisms

IV Indexing mechanisms

V Controlling means for the various mechanisms

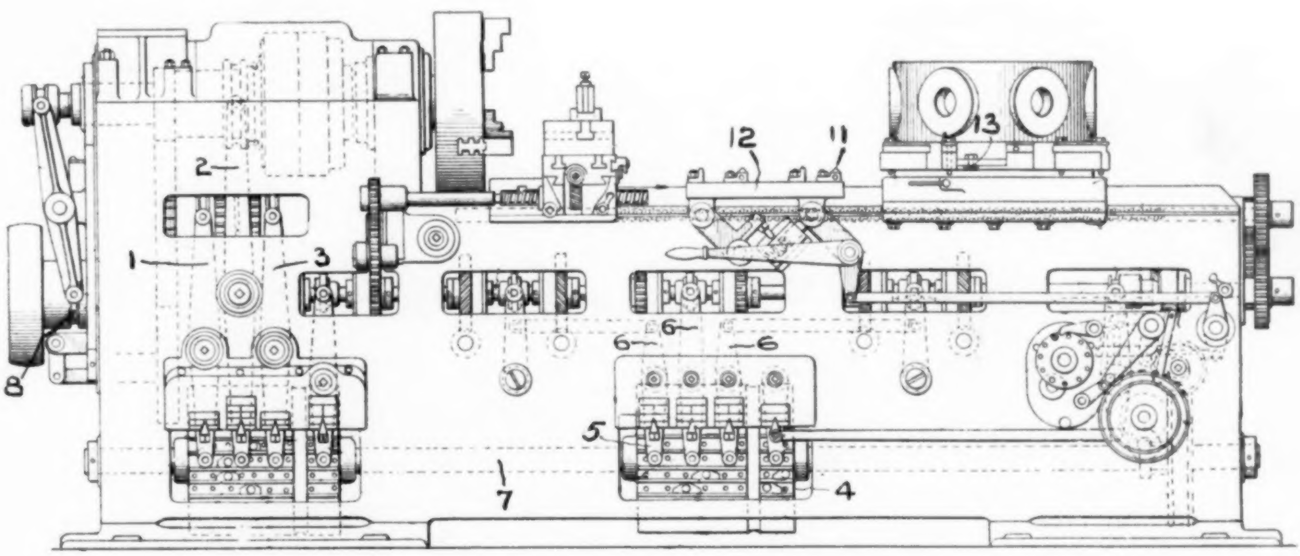

FIG. 1 AUTOMATIC LATHE WITH VARIABLE SPEEDS AND FEEDS CONTROLLED BY DOGS ON DRUMS. GISHOLT MACHINE CO.

I SPINDLE DRIVES

Features of automatically controlled spindle drives may be classified as: *a* Speed change; *b* Reversal; *c* Stopping.

Speed Change. In automatic turret machine work it is often important to have more than one spindle speed available during the operation on a given piece of work, in order that time may be most fully economized.

The automatic change of spindle speeds on machines having a constant speed motor drive is usually provided for by gearing controlled by the mechanism of the machine. Fig. 1 shows the front view of an automatic turret lathe embodying this feature. In this construction any one of eight changes of

---

Presented at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 1915. Pamphlet copies without discussion may be obtained; price 15 cents to members, 30 cents to non-members.

spindle speed can be automatically obtained, the changes being made by means of an intermittently revolving drum carrying dogs which shift levers 1, 2 and 3 as desired. Levers 1 and 3 control clutches to engage gears giving four speeds, and the number of speeds so obtained can be doubled by the operation of lever 2 which either clutches direct to the spindle for the fast range of speeds or connects through differential gearing for a slower range of speeds. The dogs on the drum may be so set as to bring the levers into idle positions, thus disconnecting the gearing.

In types of machines such as cutting-off machines or those on which squaring-up operations are largely performed, a gradual and continuous change of spindle speed is desired. A means for automatically accomplishing this is shown in Fig. 2. The automatic shifting of the belt on the tapering cones gives the desired change of spindle speed. Cam 1 is connected by gearing to the tool carriage of the machine and controls the traverse of the belt shifter 2, so that by providing the required accelerating lead to the cam, a constant cutting speed is obtained.

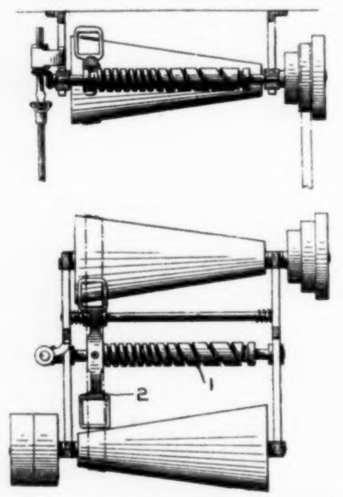

Fig. 2 Countershaft for Cutting-off Machine to Give Constant Cutting Speed

Reversal of Spindle. In designs of machines where the threading or other operations require a reversal of the spindle, this is automatically accomplished in various ways, an example being shown in Fig. 3. From the constant speed shaft 1, the spindle 2 is driven in either direction and at various speeds, the control being automatic for direction and for one change of speed. Other changes of speed are by means of change gears 4. The reverse is obtained by shifting thimble 5, engaging respectively friction clutches 6 connected by chain and sprocket with the oppositely revolving shafts 1 and 3. The shifting of the thimble is by means of a lever operated by a cam on an intermittently revolving shaft. The intermittently revolving shaft is in turn set in motion by a trip lever operated by dogs on a continuously revolving disk. The automatic change of spindle speed is by means of thimble 7 engaging respectively clutches 8 also operated by lever connection to a cam on an intermittently revolving shaft.

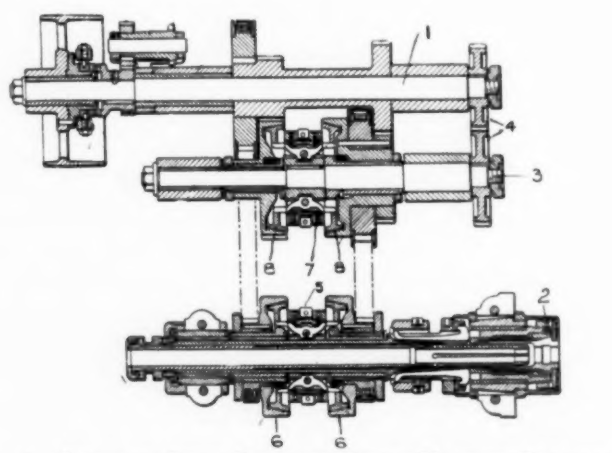

Fig. 3 Constant Speed Drive for Screw Machine Provided with Automatic Reverse and Speed Change. Brown & Sharpe Mfg. Co.

Automatic Stopping of the Spindle is required for various kinds of work. Some screw machines are so designed as to unthread the die or tap by stopping the work spindle to run the die or tap off after the threading operation. Sometimes the spindle is stopped to perform a milling, cross drilling or similar operation, and sometimes to save time in removing and replacing work when this is a hand operation.

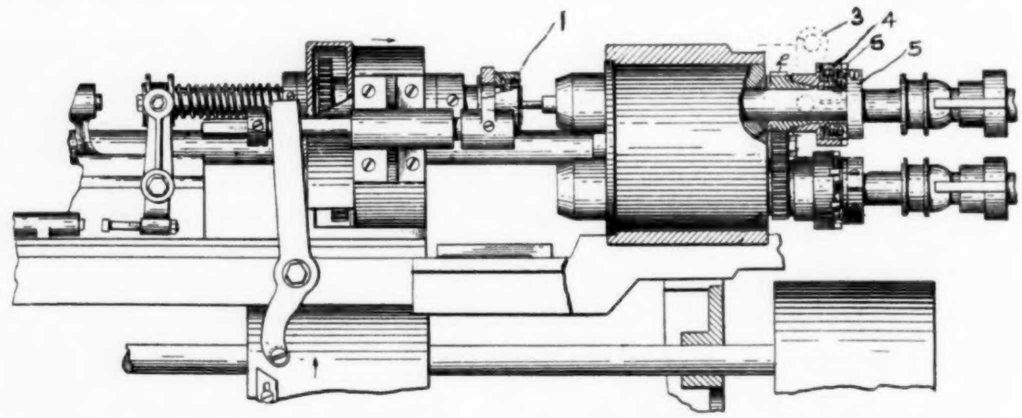

Fig. 4 Multiple Spindle Screw Machine Having Means for Automatically Stopping the Spindle. National Acme Manufacturing Company

An automatic screw machine having the feature of stopping the spindle for the purpose of threading is illustrated in Fig. 4. The revolving tap or die spindle is shown at 1, and when each successive work spindle is brought in line with it, a clutch on the constantly revolving gear 2 is disengaged by the lever 3 operated by a cam through a series of levers. This lever 3 engages a sleeve 4 which is normally in spring pressed engagement with gear 2, disengaging same from gear 2 and engaging it with collar 5 which is fast to the spindle and which constitutes a brake to stop the spindle from revolving. For heavy

work, where a positive stop is desired, a pin in collar 5 engages projections 6 on sleeve 4.

A modification of spindle-stopping means is to revolve intermittently or index the work spindle for various operations.

II Means for Inserting and Removing the Work

Means for Feeding and Holding Bar Stock. Bar feeding devices have in a general way followed the lines of the hand operated Parkhurst feed, brought out in the shops of the Pratt & Whitney Co. about 1871. The use of feeding fingers and roller feeds, in the latter case necessarily feeding against a positive stop, are forms of development which have since followed. In the former case graduated levers or scales determine the distance the stock is fed.

An illustration is shown in Fig. 5 of an automatic feeding device which can be adjusted so as to feed any required distance from zero to the full traverse of the machine. By means of the crank 1, the screw 2 adjusts a nut carrying a block 3, so that the motion of the lever 4 operated by a cam may give any desired feed to the slide 6 and thus to the feed tube, the setting being to a graduated scale. At the forward end of this feeding tube are feeding fingers to engage the bar of stock to feed it forward. After the stock is gripped by the chuck by means of chuck levers operated by a cam, the feeding fingers are retracted ready for the next operation.

By means of a special device, the machine can be stopped when the bar of stock becomes exhausted.

A well-known design of the roller principle for feeding the stock is shown in Fig. 6, where the rollers 1 engage the bar of stock and feed it forward against a stop. The driving means for the rollers consists of the circular rack 3, on the intermittently revolving ring 2, which, when held stationary, revolves the gear 4, which in turn revolves the worms 5 and the worm wheels 6, the latter being fast on the shafts carrying the feed rollers.

Means for Inserting and Removing Chucked Work. This may be considered through successive stages from the hand-operated method of the Fay automatic lathe, where the work, when it is to be finished on an arbor, is driven on one arbor by the workman so as to be ready to replace the piece being operated on when that is finished, the automatic feature in this case being the stopping of the spindle as already described.

Magazines for handling work to be chucked automatically have developed along many lines. Fig. 7 shows a tilting magazine attachment with the magazine 1 in position so that the conveyor 2 can advance to take a piece of work. After the piece of work is taken by the conveyor the magazine tilts up out of the way of the turret tools. The conveyor 2 then brings the piece in line with chuck 3 and deposits it in same. The conveyor is free to revolve so as to facilitate the pressing of the work into the revolving chuck. An ejector inside the spindle removes the work when completed.

A form of hopper for feeding studs into the rear end of the spindle is shown in Fig. 8. This might be called a reservoir magazine, as it has a widened upper portion to carry a large number of pieces. An agitator 1, operated by a lever 2, makes the feeding sure. The frame 3 is adjustable for different lengths of studs. The studs are fed positively into the back end of the spindle by the rod 4.

Large or irregular work presents many difficulties in automatic chucking, and hand methods are usually resorted to for such work. In some cases, however, automatic means have been devised for the chucking operation.

Even when placing the work in the chuck by hand, automatic devices can be made to assist in many ways. Fluid or pneumatic means can be employed for gripping the work, and this can be so applied as to reduce the pressure for the finishing cut, still maintaining sufficient to hold the work securely but without risk of distortion. Means for automatically ejecting the work can also be applied.

Means for Transferring Work for Secondary Operations. It is a common practice to transfer work from the main spindle to an auxiliary spindle or holder, after part of the operations have been performed, for additional operations such as milling, cross drilling, etc.

Fig. 9 shows a transfer holder in use for slotting the heads of screws. The transfer arm 1 is swung by the rock shaft 2 so that the hole 3 is in line with the work 4 in the main spindle and engages same before the work is severed from the rod. After the work is severed the arm 1 is swung to the position shown in the illustration. The rock shaft 2 is then fed longi-

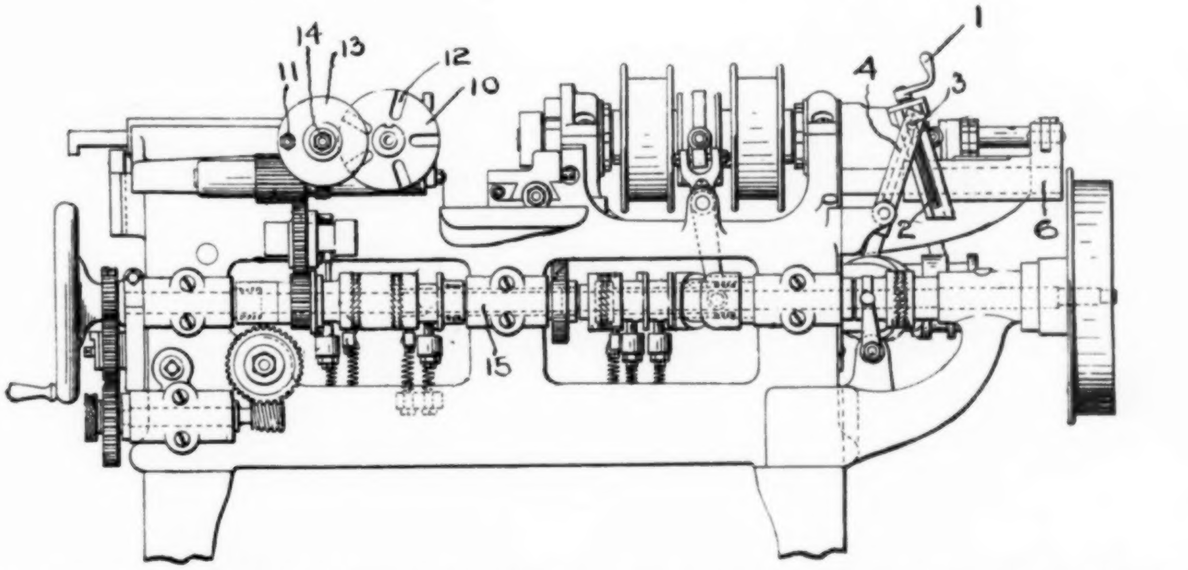

Fig. 5 Automatic Screw Machine Showing Feeding and Indexing Devices, also Use of Controlling Shaft. Brown & Sharpe Manufacturing Company

tudinally toward the saw 5, both this motion and the rocking motion being imparted by cam action.

The transfer holder can be made to turn the work end for end if desired.

III FEEDING MECHANISMS

Feeding mechanisms may be classified by the methods of controlling the movements by removable strap cams; by permanent cams, and adjustable cams and dogs; by adjustable dogs on drums; by cams specially formed for each job, and by permanently set dogs in combination with adjustable stops. The object to be attained by all these means is to save time by speeding up during the idle movements, and to provide the most efficient feed for each operation of cutting by providing a change of feed which can automatically be made effective during the operation of cutting.

Controlled by Removable Strap Cams. This type had its origin in the Spencer machines, first brought out in the early 70's. A recent development of this type of machine and one also designed by Mr. Spencer is shown in Fig. 10. In this machine the stock feeding mechanism, the tool feeding mechanism and the cross feeding mechanism are all operated by adjustable strap cams. In the case of the two former, the straps are on the periphery of drums shown at 1 for the stock feed and at 2 for the tool feeding mechanism; in the case of the last, as well as for indexing and locking the turret, they are on the faces of disks (shown at 3 for the cross slide and at 4 for the indexing).

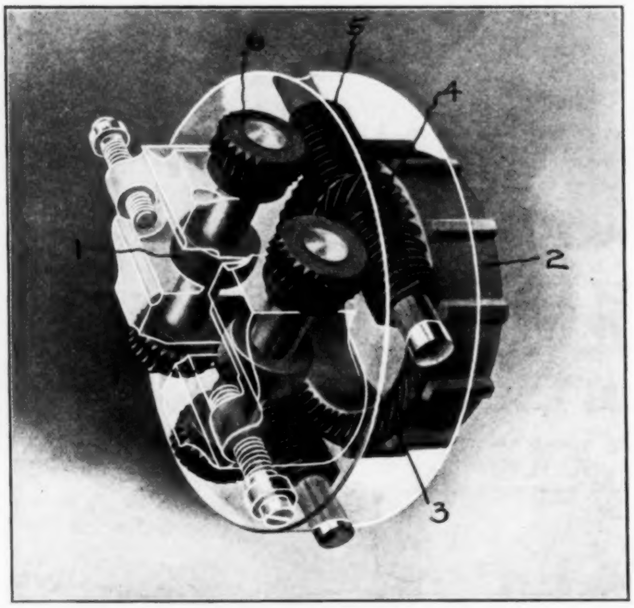

FIG. 6 ROLLER FEED. JONES & LAMSON MACHINE CO.

The machines of the Hartford Automatic Screw Machine Co. in this country, and of the Alfred Herbert Co., abroad, are among the best known examples of the use of this method of camming.

Controlled by Permanent Cams and Adjustable Cams and Dogs. An example of the combined use of permanent cams with adjustable cams and dogs is shown in Fig. 11, where the feed of the individual tool holders 1 is controlled by the permanent cam 2. The rate of revolution of this cam 2 is controlled for varying the feeding movements by an adjustable cam 3 which through roll 4 governs the position of friction wheels 5 between the disks 6. Besides this variable feeding movement, a quick movement of the cam 2 is obtained by action of the cam 7 which operates a double clutch 8 to connect either direct, giving a quick movement, or through the reduction gears 9 for the feeding movement.

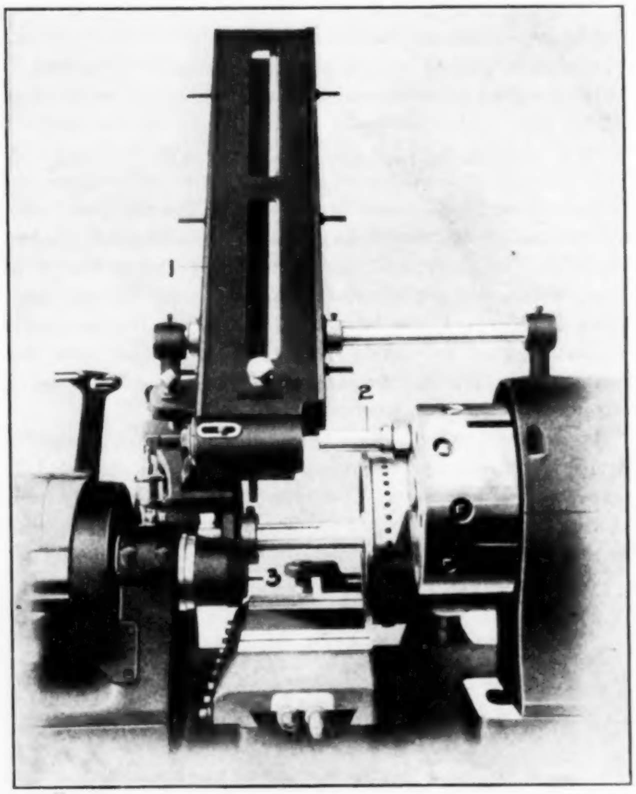

FIG. 7 TILTING MAGAZINE ATTACHMENT. CLEVELAND AUTOMATIC MACHINE COMPANY

The strap cam 10 regulates the cross feed, and this cam also

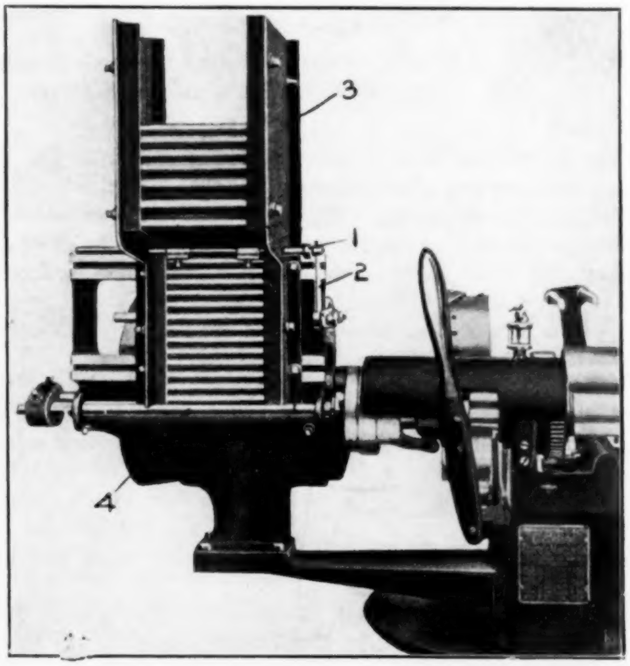

FIG. 8 VERTICAL HOPPER MAGAZINE. CLEVELAND AUTOMATIC MACHINE COMPANY

partakes of the quick and slow movements controlled by clutch 8; it thus provides for moving the cross slide forward quickly to the point of cutting and then reducing to the required cutting feed, after which it may be quickly returned so as to bring the rear tool into cutting position following which the feeding movement is again engaged.

Controlled Entirely by Adjustable Dogs on Drums. The machine shown in Fig. 1 has its movements controlled entirely by dogs on intermittently revolving drums, the only exception being the back facing device which is controlled by a permanent cam 8. For the turret the feeding is controlled by means of dogs 11 on the hinged carriage 12 engaging adjustable tripping blocks 13 on the turret, providing an independent tripping point for each tool of the turret.

Controlled by Cams Specially Formed for Each Job. The advantages aimed at by this method are the securing of the ideal conditions as to rate of feed, etc., for each operation, and the minimum time for idle movements, and being able to duplicate readily these results for the same job at any future time, the cams being marked and preserved for this purpose.

The cam operated turret feed mechanism of such a machine is shown in Fig. 12. The advance feed is obtained by the cam 1 operating through the segment lever 2 to feed the turret slide 3. The return motion is accelerated by the revolution of the crank 4 bringing the turret back quickly an amount equal to the throw of the crank.

The cross feed slides, which are independent of each other, are also operated by special cams adapted to each particular job.

In a machine for high speed work it becomes important, both in securing the desired speed and in avoiding objectionable shock, to move and reverse the lightest possible parts. For this reason machines having turrets of the "revolver" or "barrel" type, in which each spindle can be fed independently, are specially adapted to high speed work. In such machines each tool carrier is connected successively with a reciprocating feed slide, and only the feed slide with one of the tool carriers connected therewith requires to be reciprocated for the feed and return movements. Fig. 11 shows a machine of this type. In order to "speed up" still further this type of machine, the use of an auxiliary slide has been resorted to, this auxiliary slide alone being moved during that part of the quick return movements required to retract each tool and even this being disconnected for the remainder of the return movement, thus avoiding the shock which would result from the rapid movement of these slides.

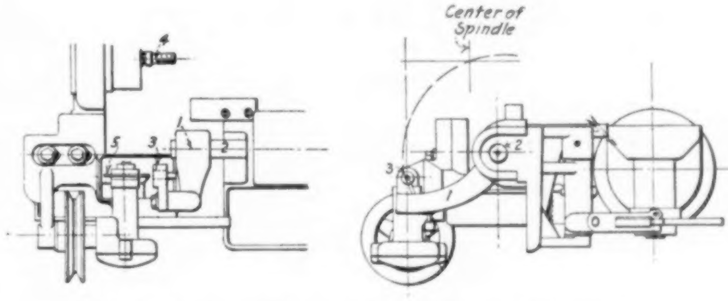

Fig. 9 Transfer Arm for Secondary Operations. Brown & Sharpe Mfg. Co.

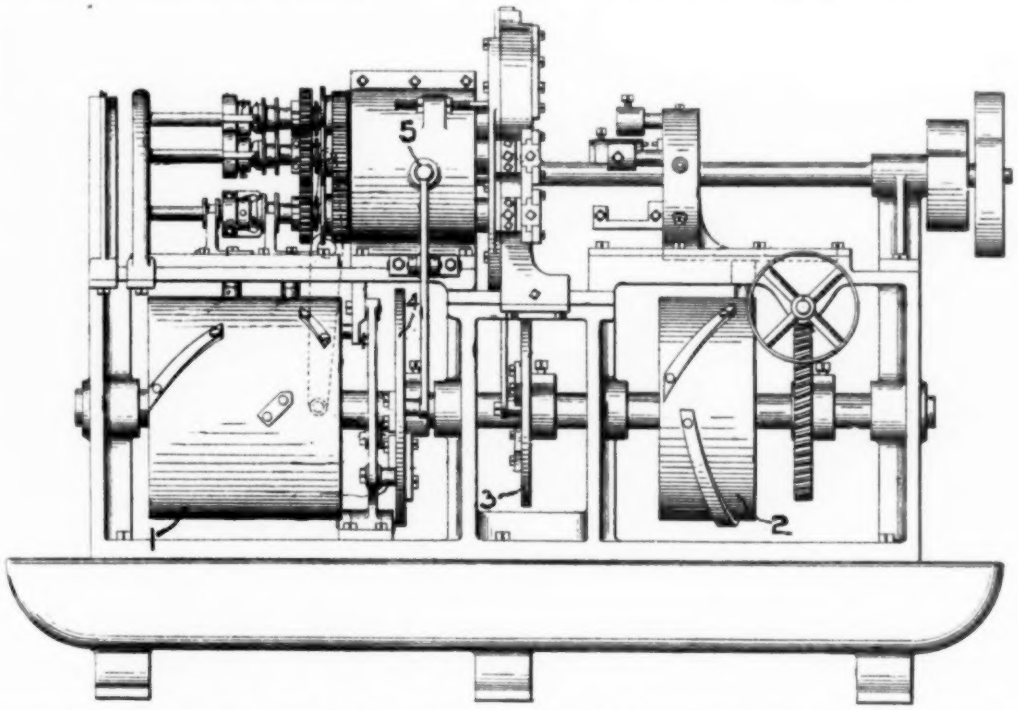

Fig. 10 Spencer Type Multiple Spindle Machine Showing Use of Strap Drum Cams. New Britain Machine Co.

Mechanism Controlled by Permanently Set Dogs in Combination with Adjustable Stops. This is a feature of the Bullard Mult-au-Matic vertical lathe, Fig. 13. This lathe has been classed by the American Machinist as a "station type machine" because the workman inserts and removes the work at one station or indexed position of the machine, while tools in the remaining positions are performing successive operations on other pieces.[1]

In this machine the rods 1 and 2 carry dogs which engage stops on the frame of the machine and trip respectively the advance and return feed movements. The quick traverse mo-

[1] For description of this machine, see American Machinist, vol 40, no. 5, p. 177.

tion, which, in addition to retracting the tools quickly, can also bring them quickly forward to the point of cutting, is operated through gears 3 and 4 controlled by clutches. The advance feed for cutting is through bevel gears 5 and change gears connecting shafts 6 and 7, the worm 8 on the shaft 7 driving worm-wheel 9. These two trains of mechanism give the desired advancing and retracting movements through connection with screw 10.

IV INDEXING MECHANISMS

Under indexing mechanisms will be treated: *a*, method of revolving turret, *b*, method of locking and clamping turret, and *c*, rectifying the indexing.

Method of Revolving Turret. A well-known method of indexing automatic turret machines is by the use of the principle of the geneva stop. This has the advantage of giving a slow starting movement gradually, accelerating and slowing down before reaching the stopping point, thus securing rapid indexing and at the same time avoiding shock. An illustration is shown in Fig. 5 where the turret 10 is indexed by the engagement of a pin 11 in the slots 12, the disk 13 carrying the pin being intermitently revolved on the shaft 14.

Methods of Locking and Clamping the Turret. It has been the general practice in turret machines to have a locking pin to automatically engage to insure the accurate alignment of the turret with the spindle and to hold the turret firmly in position while the tools are operating. Such locking pins are shown at 5, Fig. 10, and at 5, Fig. 12. In addition to the use of a locking pin, a further clamping device is often used which automatically clamps the revolving turret securely to the slide or bed and unclamps it before the next indexing.

An example is shown in Fig. 14 where the turret 1 is clamped to the turret slide 2 by the central stud 3 which is forced downward by a camming action on the projecting lugs 4. This camming action is produced by the revolving of gear 5, this gear in turn being acted on by a rack controlled by dogs acting at the desired point of the return motion of the turret slide. The locking pin for the turret is also operated from this same rack, and thus is timed with the clamping device.

Means for Rectifying the Indexing. In multiple spindle machines it is more difficult to secure accurate indexing and thus produce accurate work than in single spindle machines, because of the mechanical difficulties of constructing the machine. It is difficult to bore the spindle carrying head and mount the spindles in it so that they will be equally spaced and equidistant from the centre. To overcome such inaccuracies as are due to this cause, rectifying stops have been employed as shown in Fig. 15, one for each cross tool carrier. These consist of a series of pins 1 projecting from the disk 2, which disk is secured to the front end of the spindle head. These pins are engaged by coöperating stops 3 on the tool carriers 4 and are made so that the cutting edges of the tools carried by the tool carriers 4 will be exactly the same distance from the centre of each spindle when the pins and their coöperating stops are engaged, thus tending to counteract the inaccuracy above referred to, or any which may result from wear in the machine.

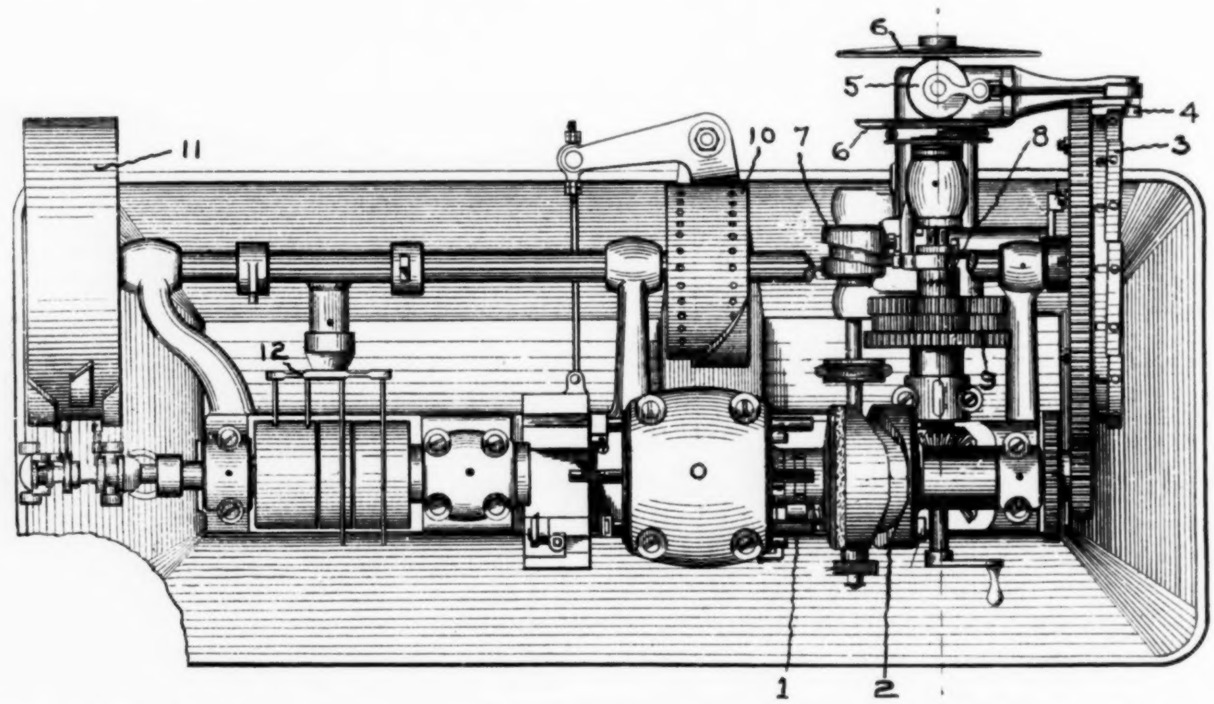

Fig. 11 Showing Control by Permanent Cams and Adjustable Cams and Dogs. Cleveland Automatic Machine Co.

V CONTROLLING MEANS FOR THE VARIOUS MECHANISMS

Aside from the ordinary practice in directly controlling the various movements of an automatic turret machine, Mr. Flanders in his paper[1] has pointed out that the use of a controlling shaft or, as he terms it, a "lay shaft," constitutes a separate type of control.

A machine with this type of control is shown in Fig. 5, where the shaft 15 drives the various mechanisms of the machine, except the spindle, and by means of clutches controls their operations.

The shaft 7 in Fig. 1 may also be said to be another type of controlling shaft, as through the interposition of dogs and levers it controls the various operations of the machine al-

[1] International Engineering Congress, 1915.

though it does not drive them. It is an application to what Mr. Flanders terms the screw feed type of machine. The Bullard machine, Fig. 13, is also of this type.

AUTHOR'S NOTE

It will be understood that in the limits of such a paper as this it is not possible to describe all machines and mechanisms devised for performing the various functions discussed. It has been necessary to select a few only and as far as possible the selections have been made of those which are typical and in the main of such as are in actual use.

DISCUSSION

C. M. Conradson[1] contributed a written discussion in which he reviewed the subject of hydraulic and pneumatic control for machine tools, citing the following as examples of the application of such control:

A device for feeding a gang drill by a direct acting hydraulic cylinder by Jesse Walrath, Supt. of the J. I. Case Threshing Machine Co., was in operation in 1889. It consisted of a multiple drill in which the table was fed up against the drills by a cylinder and piston. Pressure liquid was supplied by means of a constant discharge piston pump, the speed and stroke of the pump being such as to feed the drills correctly. A simple hand controlled valve regulated the flow of the pressure liquid to the cylinder and its escape. This machine was operated for many years and was perfectly satisfactory.

About the same time the pneumatic chuck was brought out and patented by a Chicago inventor. This patent disclosed all the essentials of the pneumatic chuck, consisting of a collet, closing tube, axial pressure cylinder with piston, retracting means, and three-way actuating valve.

F. W. Taylor, while superintendent of the Midvale Steel Co., designed and patented a hydraulic device for taking up the backlash of the forming slide used to form steel tires in the boring mill or lathe. This device merits the closest study, as it strikes at the root of the most serious trouble encountered in the use of broad cutting tools in machines. Taylor initially strained the tool holder in the same direction as it was strained by the cut, and thereby overcame chatter and "hogging in."

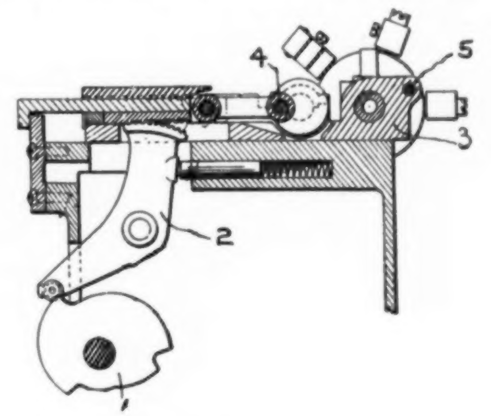

Fig. 12 Feeding of Turret Slide by Cam Specially Formed for the Job—Additional Quick Return Device. Brown & Sharpe Mfg. Co.

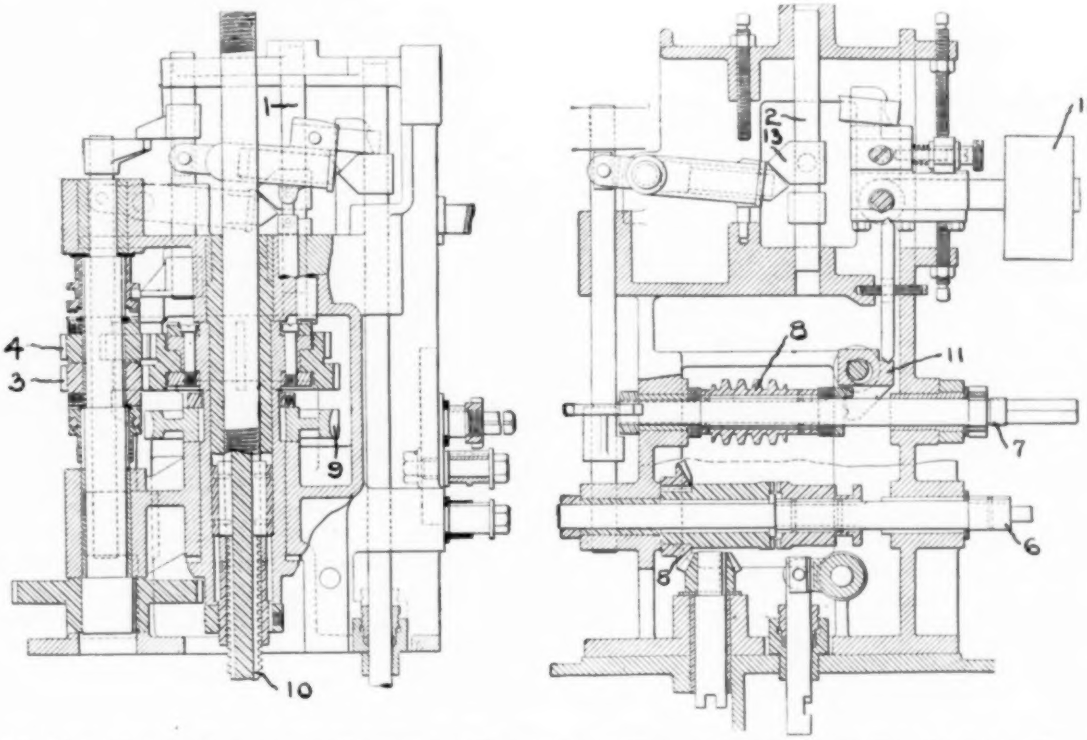

Fig. 13 Tool Device Having the Feature of Tripping the Feed if Pressure on Tool Becomes Excessive. Bullard Machine Tool Company

Taylor also invented and patented an extremely ingenious feed motion for boring machines, consisting of an axial cylinder and piston acting directly on the boring tool and restrained by means of a mechanical let-off device consisting of a threaded bar, a rotary nut, and suitable actuating mechanism, which rotated the nut at the proper rate to secure the desired feed. The hydraulic piston supplied the necessary pressure to feed the tool to the cut. By this means all backlash was eliminated, as well as the tendency to dig in.

Probably the first example of an hydraulically actuated

[1] Phoenix Mfg. Co., Eau Claire, Wis.

automatic machine tool is afforded by the writer's automatic lathe patented in 1893. In this machine a differential cylinder made integral or attached to the frame of the lathe actuated a piston attached to the turret slide. Pressure liquid was supplied to the large end of the cylinder by means of an automatically actuated valve controlled by an adjustable stop bar geared to rotate in unison with the turret. This stop bar was arranged with its axis parallel to the axis of the lathe and was carried by the turret-slide. The bar was hexagonal in general outline, and on each of its faces were arranged cam blocks for controlling the valve; as the cams came into action successively, it was possible to begin feeding at any desired point for each tool, and also to stop feeding at any point. The rapid traverse of the turret was likewise controlled by the stop bar, and was very rapid.

In a machine built in 1892, the traverse of the turret was 75 ft. per min. While this machine worked perfectly in all shop tests, further experience showed the desirability of changing the throttling control to a positive feed obtained from a variable delivery pump.

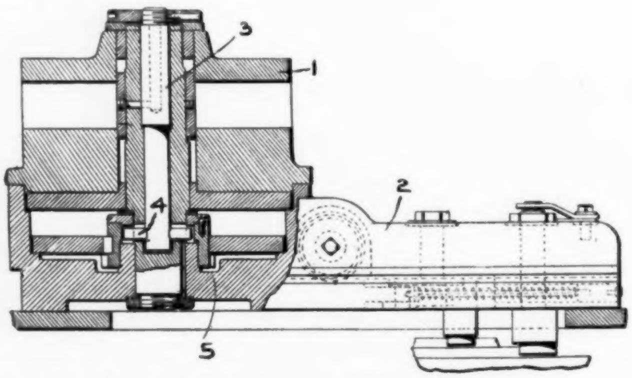

FIG. 14 CLAMPING DEVICE FOR TURRET. POTTER & JOHNSTON MACHINE COMPANY

James Hartness developed a hydraulic feed turret lathe in which the turret was actuated by a cylinder and piston; the chief novelty of this machine was in the method of obtaining the pressure liquid by means of compressed air acting on the surface of the liquid contained in a tank.

Pneumatic clamping of work in jigs was developed largely by B. M. W. Hanson, Supt. of the Pratt & Whitney Co. Such jigs are now in general use in automobile factories for holding cylinder, pistons, etc., while being operated on. Pneumatic clamps are used on plate planers to great advantage. Pneumatic vises have been in use for several years for assembling valves, fittings, etc.

Pneumatic chucks are generally used for rapidly chucking work on lathes, screw machines, etc. They are made in the original form, using collets, and also are made with radially moving jaws. This type of pneumatic chuck is especially valuable, as false jaws can be readily fitted. It can also be made to any size desired, and is in use for holding car wheels.

The writer has recently patented the application of the pneumatic chuck to multiple spindle lathes, each spindle being provided with a cylinder and piston, communicating piping, and individual valves by which the chucks can be opened and closed when the spindle is in chucking position.

B. M. W. Hanson patented in 1909 an automatic lathe operated by fluid pressure. The claims were especially directed to the indexing mechanism, all of the motions being controlled by a number of pistons.

Perhaps the most complete example of a fluid pressure controlled machine tool is found in the writer's multiple spindle automatic lathe. This was described in detail in the *American Machinist,* June 25, 1914. The power and precision of hydraulic control is strikingly examplified in these machines. In the large size, the spindle carrier weighing more than 10 tons is handled with perfect ease and is locked with perfect accuracy.

An illustration showing the exceedingly close limits attainable by the use of fluid control is the pneumatically actuated plate drilling machines employed by the Waltham Watch Company. In these machines, the watch plate is mounted on a platen arranged to move in two directions at right angles to each other. These motions are obtained by pneumatic cylinders and pistons, and are limited by rotating stop bars. The machine is automatic, and the work produced has necessarily to be practically perfect.

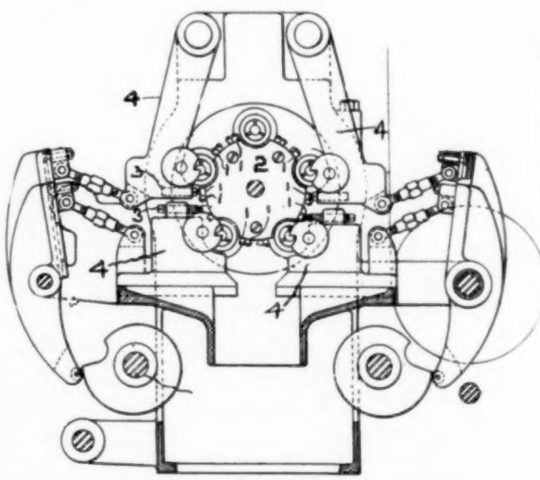

FIG. 15 MEANS FOR RECTIFYING THE INDEXING OF MULTIPLE SPINDLE MACHINE. DAVENPORT MACHINE CO.

In the hydraulically actuated shaping machine designed by the writer, the cylinder is cast integral with the frame and the piston rod is attached at the ends to the ram. The piston is in the central part of the rod, and pressure liquid is alternately admitted to the ends of the cylinder through suitable ducts. A multi-cylinder valveless pump is employed, having a shifting crank pin. The crank pin is shifted from side to side by means of an escapement tripped by tappets on the ram; the effect is to reverse the flow of the liquid and thereby cause reversal of stroke. In one particular size of this machine, the relief valves are set at 400 lb. per sq. in., giving an available pressure at the tool point of 5 tons. The ram travels up to 100 ft. per min. in either direction and without change, other than that the tool holder can be used for either push or draw out. The pressure in the cylinder rises in accordance with resistance due to cut.

A recent development in hydraulic control is the grinding lathe built by the Greenfield Machine Company; in this a stationary cylinder is employed, the piston being attached to the platen of the machine. A valve actuated by tappets operates to admit and exhaust pressure liquid to the cylinder.

A very important use of hydraulic or pneumatic pressure is for operating friction clutches for starting, stopping, or reversing moving parts. These clutches are very similar in many features to the air chuck, and are used with great success in planers, slotters, lathes, etc. Such clutches have been designed by Wm. Sellers & Co. and by John Riddell. The pneumatic clutch is easily operated, is very durable, and possesses the

great advantage that it is self-compensating for wear. Weston hydraulic clutches have been built transmitting up to 1000 h.p. At the present time, when the use of compressed air is nearly universal in machine shops, it is actually cheaper in many cases to use pneumatic clutches than mechanically actuated clutches.

There are many minor uses for compressed air in machine tool practice, such as lifting clapper boxes of planer, lifting planer tools directly out of the cut, actuating tools on automatic machines, etc.

RALPH E. FLANDERS. One of the things in favor of the hand machine for large work is that with it higher speeds and feeds can be used in many cases than in an automatic machine. On an automatic machine the speeds and feeds have to be kept down to such a point that nothing serious will happen while the operator is away, attending to one of his other machines. The operator running the hand machine has his eye on the work constantly, and it is safe to run at speeds and feeds which are not safe for an unattended machine.

Furthermore, at times the automatic machine has to be so set that the slow feeding movements will start at a reasonable length of time before the tool actually strikes the work, losing a little time there. This does not mean that the automatic machine will not occupy a larger field every year in certain kinds of work.

One further type of mechanism should be added to the classification of spindle drives. This is the type where a change is made in the relative movement of work spindle and tool carrier. Each one of the author's speed classifications comes under this head of change in the relative movement, strictly speaking; but the particular application I have in mind is used, if I remember correctly, on the Gridley multiple spindle. In that machine the tap or die may be run at a slower rate of speed than the work for threading on, and then at a faster rate of speed than the work for threading off, without changing the rate of speed of the spindle. Perhaps, therefore, this feature does not come in the classification of spindle drive at all, though it has the effect of some of the other methods Mr. Burlingame has mentioned under this classification.

ELMER H. NEFF. Mr. Burlingame's paper would appear to use the word "control" with a different interpretation from the paper presented by Mr. Brooks. The latter has used the word "control" in the ordinary sense relating to the method of conveying to the machine tool its power for operation, while this paper covers the field of devices applied to screw machines and lathes for automatically performing the work for which they are designed. In other words it relates to the details of design of the tools. A great deal of interesting information has been collected to cover the elements of the machines as listed in the paper.

I should question the elements, *Means for Inserting and Removing the Work,* and *Feeding Mechanisms* in the analysis. The term feeding mechanism in connection with screw machines has come in actual practice to be confined to the operation of feeding out the bar by a wire feed mechanism preparatory to performing the cutting operations. Mr. Burlingame realizes this as is evident from the use of the term "is fed" later in the paper. I think, however, that the second element above should read, "Mechanism for control of operation of cutting tools." The first element above would be more properly labeled, "Feeding mechanism" or some similar title.

Referring to the paragraphs on speed change, I would suggest as a still stronger reason for having incorporated in an automatic screw machine the possibility of changing its spindle speeds automatically during the series of operations going to make up a finished piece, that the presence of this possibility enables the designer of the tools to secure a larger output from the machine. The reason for this larger output is that some pieces of work, especially in castings, will have cutting operations on diameters quite different in size from each other, so that if the small diameter has to be machined at the same rate of rotation as is demanded by the limitations of cutting speeds on the large diameter, the product of the machine is cut down to a low ebb. A further illustration is in the fact that threading must be done at a relatively slow speed as compared with turning operations.

In former years it was a common idea among those who were prospective purchasers of automatic screw machines, particularly among those who had not used such machines, that a cheaper class of labor could operate them. Experience has shown this idea to be a fallacy. As a matter of fact, if there is any difference at all, it requires a higher degree of skill to operate an automatic screw machine than it does a hand screw machine. The skilled operator attending from four to seven or more machines is sometimes assisted by a helper who can slip a bar of stock through the feeding finger, and throw the starting lever, but that is not operating the machine. These screw machine operators are not necessarily machinists by trade, but they should be highly skilled specialists in this particular work. The statement in the paper with regard to greater skill required to keep the machine in running condition is correct, and evidently is contrary to the statement that less skilled labor can be applied.

Automatic screw machines are successfully performing the work indicated by the following classification:

a Producing pieces from bar stock (bar brass, machinery steel, drill rod, etc.)

b Second end operations on pieces produced by classification *a*. In this section the work is fed into the chuck automatically from a magazine or hopper.

c Machining operations on blanks such as punchings and small castings. The work is automatically fed into the chuck in such cases usually from a chute, the only requisite being that if they are castings they shall not vary in roundness or size more than the elasticity of the chuck will allow.

d Performing the machining operations on pieces inserted by hand in the chuck. These are usually castings of such irregular shape or size that they cannot be handled or inserted from a chute automatically.

I have recommended and installed a multitude of automatic machines during the past 18 years, covering operations along the classifications suggested. I cannot agree with Mr. Flanders in his discussion of this paper that automatic machines must run at a slower speed than hand machines unless his statement should be limited in its application to castings. The machining operations on castings are liable to be considerably curtailed in speed on account of the variations in their hardness, and also on account of the liability that they may have incorporated in them slag or other hard substances that will destroy the cutting tools, and spoil considerable work, before the operator discovers the injury to the tools.

There is no direction in which the general machine tool industry is growing more rapidly than in the field to which automatic screw machines as analyzed above can be applied. The reason for this growth is readily understood by those who have used automatic screw machines because their installation, almost without exception, has shown very large savings in cases

of producing manufactured goods. At the same time it should be noted, in passing, that practically all the gears used in this country are produced on automatic gear cutting machines. Also that the cylindrical grinding machine, which has developed very rapidly, is a semi-automatic machine, that is, one which produces automatically in many cases the finished operation after the piece has been inserted in the machine by hand. Furthermore, some progress has been made in the development of completely automatic grinding machines, which insert their work automatically from a chute.

NORMAN MARSHALL inquired whether it was necessary to install automatic stopping devices on these machines to take care of accidents, and what was the state of their development.

H. K. HATHAWAY said that the contrast between what has been done in the way of automatic control in machine shops and in other lines of industry, had struck him very forcibly in the last few years.

In the textile and other allied industries, particularly, there has been much done in the way of the automatic stopping of machines when anything goes wrong, as well as other features of automatic control. In machine shops, however, the use of automatic control has, comparatively, been very limited.

THE AUTHOR. As to the differential rate of speed of spindle and work, which Mr. Flanders mentions, it is interesting to note that the patent records show that practically every imaginable combination of running forward and backward, starting and stopping, has been patented at some time, probably without the claims being of any great value. All combinations for control of spindle speeds might be classed under one heading, whether they are for stopping the spindle entirely or for slowing it down thus giving a differential speed.

There are some factors of automatic control to which study has been given but which are not included in this paper. One is the supplying of oil to the point of the drill, in a turret machine, so that the oil is shut off as soon as the turret is indexed to another position, and restarted whenever the drill is in line.

I agree with Mr. Neff that the use of automatically controlled machines increases the need of skilful supervision. In fact this statement is made in the paper. It is simply that less skilled men can be used as helpers on automatic machines; but there must be somewhere up and down the line someone with a high degree of skill for the purposes of supervision.

Men who are not fully trained mechanics can sometimes be instructed so as to become skilful in operating automatic machines. These are men adapted to this work, who become skilled in a sense, although not classed as skilled "all around mechanics." I do not wish to convey in the paper, however, any thought but that skilled supervision and skilled men are needed to operate these machines.

In reply to Mr. Marshall, it is a plan in many types of machines to have a breaking or friction point which will break or yield first and thus prevent breaking any of the important parts. The machine so constructed can be readily started up again without waiting for expensive repairs. This feature might be very aptly classed as one of automatic control, but not in the usual sense in which the mechanism for operating the machine is meant.

On the Bullard machine (Fig. 13) is a thrust for the worm which will allow it to give if the pressure is exceeded, and will trip the machine so as to stop its feeding. This illustrates in another way the point made by Mr. Marshall.

ELECTRIC OPERATION AND AUTOMATIC ELECTRIC CONTROL FOR MACHINE TOOLS

BY L. C. BROOKS, SCHENECTADY, N. Y.

Associate-Member of the Society

THE application of electric control to individual machine tools is considered to be one of the most important forward steps in the improvement of machine shop efficiency. The economies resulting from substituting electric drive (either individual or group drive) for the steam engine and long line shaft drive were very effectively outlined before this Society six years ago.[1] Prof. W. F. M. Goss too has stated: "I am convinced that the machine tool of the future is to be an individual motor driven machine, a machine in which we shall not see pulleys, belts or gears."

In the early application of electric motors to machine tools, the motors were started by hand starters, either of the dial, or drum type, the dial type usually being unprotected. However, these conditions are now entirely reversed by use of Safety First requirements and remote controlled automatic controllers.

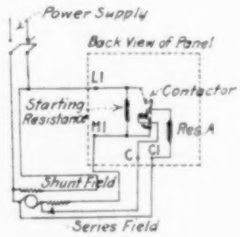

Fig. 1

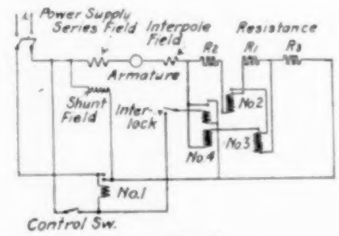

Fig. 2

FIG. 1 CONNECTIONS OF C. E. M. F. AUTOMATIC STARTER

FIG. 2 CONNECTIONS OF SERIES TYPE STARTER

During the past year, the A. I. E. E. has held a series of meetings under the auspices of the Industrial Power Committee. The subjects treated included the characteristics of electric motors; factors involved in motor applications; fields of motor application and controllers. These articles contained a vast amount of valuable data and information relative to their subjects and to present practice, and it is understood that they will be published in a special volume. All who are interested are referred thereto, as any attempt to give an abstract here would be unsatisfactory.

CONTROL APPARATUS

While there are a number of instances and special locations where dial or drum type hand starters are more applicable, we have reached the time when automatic starters, remote controlled (with the possible occasional exceptions of the reversing switch), are the most suitable. The principal advantages of automatic control are:

a The use of manually-operated controllers may cause undue stresses on the motor, especially on rapid reversing equipments

b The operating switch, or push button, is easily attached to the machine and the main panel may be located at a distant point, out of the way

[1] Trans. Am. Soc. M. E., vol. 32, p. 219; also, Proc. A. I. E. E., vol. 29, p. 621.

Presented at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 1915. Pamphlet copies without discussion may be obtained; price 10 cents to members; 20 cents to non-members.

c The manufacture of automatic appliances is now a well founded art and is no longer an experiment

d A considerable increase in the capacity of the machines is obtained

e The starting time is automatically regulated to suit the load conditions on the motor

f Accurate stopping points are obtained by the application of *dynamic braking*, which consists in connecting a resistance across the armature circuit in the *off* position of the starter, the stored energy of the armature being dissipated as heat in the resistance

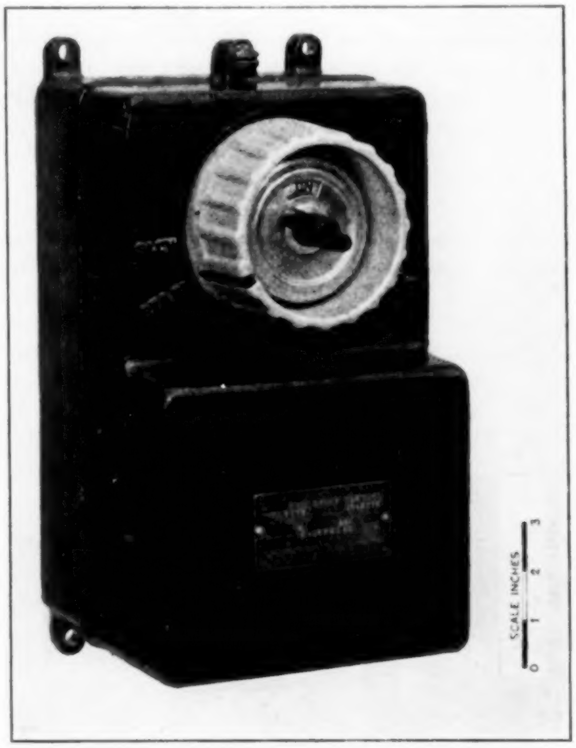

Fig. 3 Starting Panel for Small Motor

g It permits the use of operators not specially trained. It entirely removes the element of thought from the mind of the operator who has simply to operate the master switch or push button in the desired direction and does not need to think about drift points, safety features, etc.

TYPES OF STARTERS

The three general types of automatic starters are time element, counter e.m.f. and current limit. Fig. 1 shows a connection of a counter e.m.f. starter with one step of starting resistance, and line switch in motor circuit. A simplified wiring scheme of a series type of starter is shown in Fig. 2.

All panels, whether for general starting duty, or for control of special machines, should be provided with a suitable enclosing case, for the protection of the appliances on the panel against injury, also for the protection of the operator against accidental contact with current carrying parts. With starters for motors of small capacity the enclosing case should be fool-proof and meet all the applicable Safety First requirements. Under ordinary conditions, the control panels for motors of large capacity should be provided with small openings to allow for the radiation of heat from the current carrying parts. In many cases, it will be found very desirable to make the enclosing case as a part of the casting of the machine frames.

STARTER FOR CONSTANT SPEED MOTORS

A starter for small adjustable speed motors of ¾ h.p. and less, where starting resistance is not necessary, is shown in

Fig. 4 Woodworking Lathe with Starter in Headstock

Fig. 3. It consists of a line contactor, an overload relay, a field rheostat and connection board, mounted on the insulating base and enclosed in a Safety First case, which is adapted for conduit wiring. This starter is arranged to always start with full field on the motor by simply turning the field rheostat handle to the extreme left, thus closing the line contactor, after which the rheostat handle may be turned to the point for the

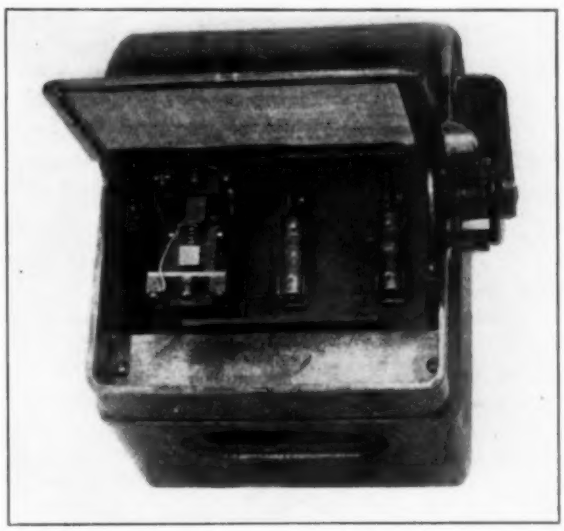

Fig. 5 D. C. Starting Panel. Max. Rating 3 H.P. at 230 Volts

desired motor speed. If desired, an "emergency stop" push button may be located at any convenient point on the machine. This starter is especially adapted for headstock motors, woodworking machines, etc. Fig. 4 shows a wood-turning lathe with the starter self-contained in the lathe frame.

A starter for motors of ¾ to 3 h.p., where one step of starting resistance is necessary, is shown in Figs. 5 and 6. The appliances on the front of the panel consist of line switch and

fuses, (1) contactor, (1) counter e.m.f. accelerating contactor, and connection board. The starting resistance is mounted on the back of the panel. The complete panel is enclosed in a Safety First case, the chief features of which are:

a The switch operating handle may be locked in position, thus preventing unauthorized operation

b A hinged door is provided for the examination of the panel and renewing the fuses

c There is an interlock between the operating handle and the cover of the enclosing case, so that the cover cannot be opened until the switch is open and the switch cannot be closed until the cover is closed, thus preventing any injury to the operator as a result of accidental short circuits. This starter is arranged for push button operation and the enclosing case may be fitted for conduit connection.

For starters of larger horsepower, arrangement *c* would be somewhat modified to accommodate the additional accelerating contactors. A double pole line contactor should also be supplied. The questions of type of overload appliance and whether or not a dynamic braking contactor is necessary depend upon the application. The enclosing case should be of sheet steel, for appearance and light weight, and the interlocking features described above are not necessary.

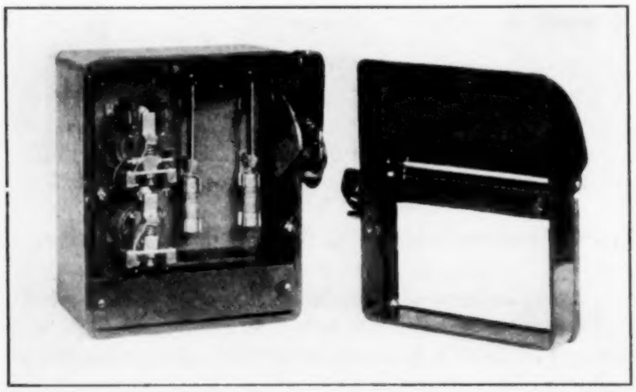

FIG. 6 D. C. STARTING PANEL. MAX. RATING 3 H.P. AT 230 VOLTS

STARTERS FOR ADJUSTABLE SPEED MOTORS

For general service, the starters for adjustable speed motors should be of the same general design as described above for constant speed service.

The starting resistance should be mounted back of the panel, except in the case of large sizes of motors when it should be separately mounted. The field rheostat should be mounted separate from the panel, with the possible exception of small sizes of motors. The method of control should be at the panel or remote, as operating conditions require.

REVERSING SERVICE

For general reversing service, the starters should be of the same general design and requirements as given above for nonreversing, with the following modifications:

a Dynamic braking at the "off" position should be supplied to protect the motor

b Two double line contactors are necessary to give the reversing. In small equipments, a double pole, double throw switch may be used for reversing.

GENERAL SERVICE

The types of starters described above are applicable for all general service, as pumps, fans, drill presses, grinders, milling machines, and boring mills, except in cases where special features are desired.

PROTECTIVE FEATURES

All automatic starters and control apparatus should be provided with protection from low voltage on the line, also from excessive overload. In all cases, except possibly pumps and fans and similar machines, these protections should be of such a nature as to disconnect the motor from the line, and not to be restarted except by the operator at starting station. For motors of over 25 h.p., the overload protection should be preferably an overload relay, either hand or electrically reset, as operating conditions require. For motors below 25 h.p., the overload protection should be fuses, chiefly for economic reasons. The fuse capacity should conform to the requirements of the National Board of Fire Underwriters. In many cases it will be preferable to have the line switch and fuses a part of the distribution system, separate from the control panel.

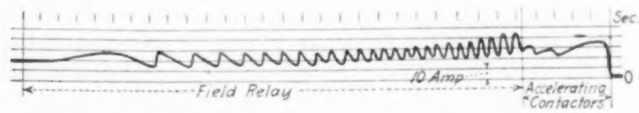

FIG. 7 5 H.P. MOTOR STARTING CURRENT CURVE

With adjustable speed motors, it is desirable to set the field rheostat so that the motor will always operate at a predetermined speed. To accomplish this, connections should be such that the field resistance is short-circuited during the accelerating period, thus permitting the motor to start under maximum torque. (This connection to be reëstablished when the motor is stopped, thereby giving maximum torque for the dynamic brake cycle). After the armature resistance is cut out, the field is then automatically weakened to the predetermined point. In order to prevent the motor from accelerating too fast, thereby drawing excessive current from the line, the field accelerating relay should be supplied. This relay is connected in the armature circuit with auxiliary contacts which, when closed, short-circuit the field rheostat and as the relay operates

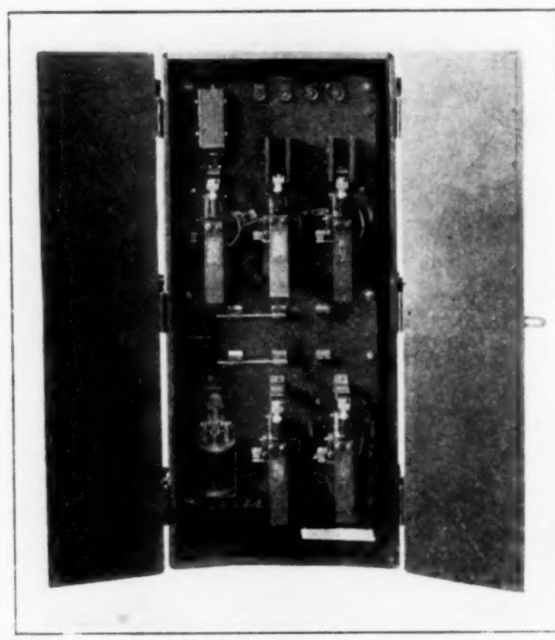

FIG. 8 WHEEL LATHE CONTROLLING PANEL

alternately cut the field rheostats in and out as the motor increases from full field speed to the desired fast speed, thereby preventing the high current inrushes on the motor. This method also permits of quickly obtaining full speed and prevents severe field distortion due to high armature currents. These relays are unnecessary on motors below 5 h.p., and on motors of less than 50 h.p., with a speed range of 2:1, except in special cases where the time of bringing acceleration up to speed, with 150 per cent load, is many times that of the field constant.

Fig. 7 is a current curve when starting a 5 h.p. motor, 500/1500 r.p.m., flywheel load, showing the starting peaks, also how the field relay regulates the current.

With adjustable speed motors of a range of greater than 2 to 1, provision should also be made so that the field resistance is not cut in until the last accelerating contactor has closed, thereby cutting out the last step of starting resistance. Provision should be made so that the motor fields are not energized when the machine is not in use.

With adustable speed motors, too, especially with a range of 4 to 1, arrangements should be such as to prevent a "pump back" when stopping the motor.

On work requiring quick reversing, dynamic braking should be provided at the "off" position of the starting switch. In many cases, as on planers and boring mills, a graduated dynamic braking of two or more points is necessary.

RESISTANCES

In connection with starting apparatus, one of the most important items for consideration is the starting resistance. Except in cases of small motors, cast iron grids are very satisfactory for this service. Cast iron has a temperature coefficient of about 0.0007 and by adding a small per cent of certain alloys, a very high resistance grid is obtained which is suitable for rather small size of motors. For small motors, a high resistance wire, or ribbon, is suitable, which may be in the form of enclosed coils, flat plates or other special forms as the various manufacturers develop the material. A motor starting a load which is subject to infrequent overloads of short duration should have a resistance unit of large thermal capacity, while a motor subject to frequent overloads should have a resistance unit of small thermal capacity in order to give more rapid cooling. In all cases, the resistance units and their mounting should be of rugged construction and properly supported to be conveniently accessible.

The N.E.L.A. has proposed the following requirements for direct-current motors, as to maximum starting current, for 230 volts, which is the average factory voltage:

3 h.p., and below.....12 amperes per h.p.
Above 3 h.p.......... 9 amperes per h.p.
No motor may be connected without a starting resistance where the starting current exceeds 30 amperes.

Table I gives the number of steps of starting resistance which should be required for general service. Of course, there will be instances where it will be desirable to depart from this schedule, to meet peculiar operating conditions.

TABLE 1 NUMBER OF STEPS OF STARTING RESISTANCE

Horsepower........	Below 1 h.p.	1-3	5-25	30-50	60-100	110-200
No. of Steps........	Direct on line	1	2	3	4	5

APPLICATIONS OF AUTOMATIC CONTROL

With the foregoing general requirements for appliances, and with the following typical special examples described, it is not hoped to have universal agreement. In fact, it is hoped that the criticisms will be wholesome and that other suggestions will be numerous with the result that the Sub-committee on Machine Shop Practice may undertake the task of formulating specifications for standard electrical equipments for machines of the various services.

The importance of standardizing cannot be too strongly emphasized. By this is not meant that the detail appliances should all be of the same design—the various electrical manufacturers can work that part out for themselves—but that the control equipment for a certain type of machine should contain a uniform set of appliances. The space required by every electrical manufacturer would thus be practically the same and the machine could be so designed to accommodate the electrical equipment, with the result that the complete installation would be much neater in appearance and more satisfactory in every way.

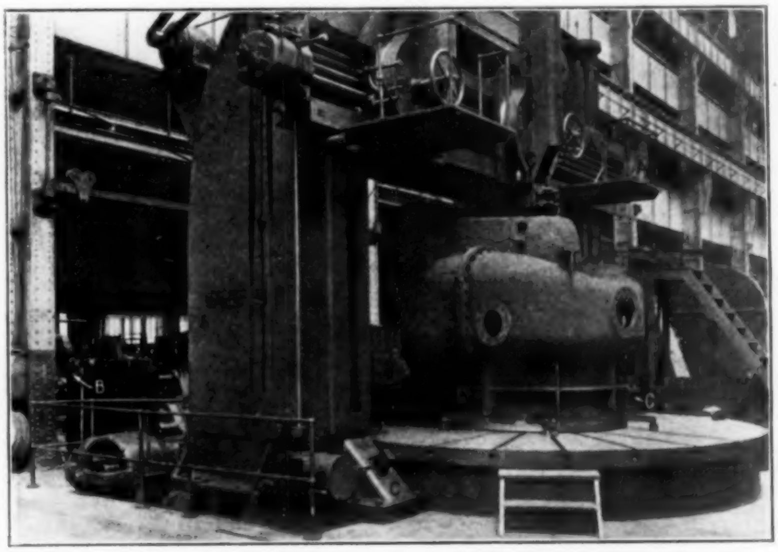

Fig. 9 Boring Mill with $7\frac{1}{2}$ and 50 H.P. Motors

Lathes. At the present time the problem of *purely automatic control* for general lathes has not been entirely solved. For many uses, the drum controller has been found to fill the requirements quite satisfactorily. An automatic starting panel with a drum switch for reversing has given good results for certain applications. Lathes for a special class of work have been controlled with safety and efficiency, so that it is believed the day is not far distant when the goal for general lathes will have been reached.

Car Wheel Lathes. The functions of a car wheel lathe require that electrical equipment be designed for especially heavy service and that the control be reliable and as simple as possible. The equipment should consist of the panel and resistances, a push button station with "start," "stop" and "slow down," and a pendant or foot switch for "slow down," the "slow down" feature being necessary when a hard spot is reached in the cut, and "slow down" being to approximately 50 per cent of basic speed at 100 per cent load. After the "slow" button is pressed, it should always be necessary for

the motor to come to approximately full field speed before it is possible for slow down contactors to be closed again, to limit the "pump back."

The starting, brake, and slow down resistance should be mounted on the back of the panel, when the size will permit, the field rheostat being mounted separately. The enclosing case should be of sheet steel and provided for either wall or floor mounting. A panel for 50 h.p. is shown in Fig. 8.

Boring Mills. The control equipment for a boring mill presents many interesting problems, among which are:

a Where the mill is operating upon heavy castings, it should be accelerated slowly on starting

b Dynamic braking should always be supplied when stopping to insure efficient stops, also to prevent damage to the motor by improper manipulation of the starter

c The control scheme must be such that no possible combination of operating buttons will permit the motor to run on starting resistance when the load is decreased, or produce a "pump back" with consequent heavy sparking at the motor when stopping.

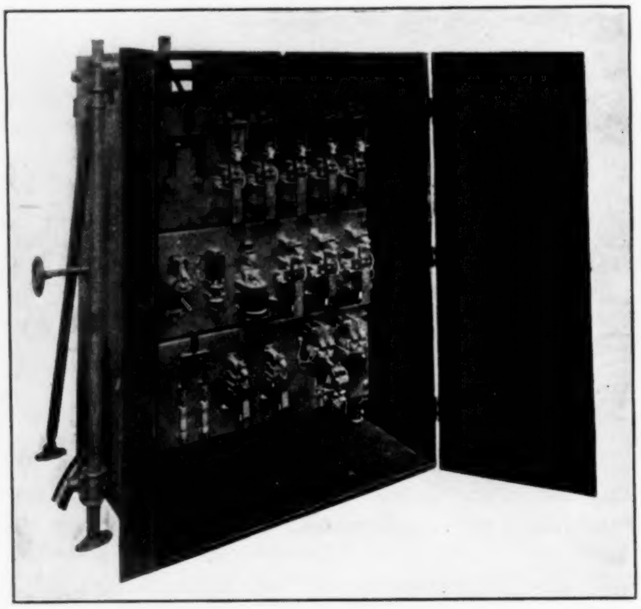

FIG. 10 CONTROL PANEL FOR $7\frac{1}{2}$ AND 50 H.P. BORING MILL MOTOR

Fig. 9 shows a William Sellers 18-ft. boring mill operated with $7\frac{1}{2}$ and 50 h.p. motors controlled by panel. *A* is the rapid transverse and feet control station, *B* the motor panel and *C* the main motor control station. Fig. 10 shows a control panel for a 50 h.p. and $7\frac{1}{2}$ h.p. combination boring mill motor.

Planers. The applications of electric motors and their control to planers, slotters, etc., is probably the most interesting, from an engineering point of view as well as that of economy in production, of all machine tool applications. The relative advantages and economies of the reversing motor drive for this purpose are now fully realized and have been set forth in bulletins issued by the various electrical manufacturers. They are also thoroughly appreciated by all machine tool men, so that a summation of them will be unnecessary. However, the main electrical points to be kept in mind are:

a Sparkless commutation of the motor

b Stability of the motor at all speeds

c Gradual dynamic braking (to prevent undue shock on the machine) in the shortest possible time

d Quick reversing

e Independent cutting and return speeds with maximum range of 4 to 1

f Provision for minimum drift when the motor is stopped or reversed, also when the power fails as a result of overload or low voltage on the line

g Auxiliary contacts on the contactors reduced to a minimum

h Provision for position operation of the main contacts

i "Time efficiency" for the complete cycle as high as possible

j All the appliances of the control equipment designed so as not to be influenced by reasonable vibration.

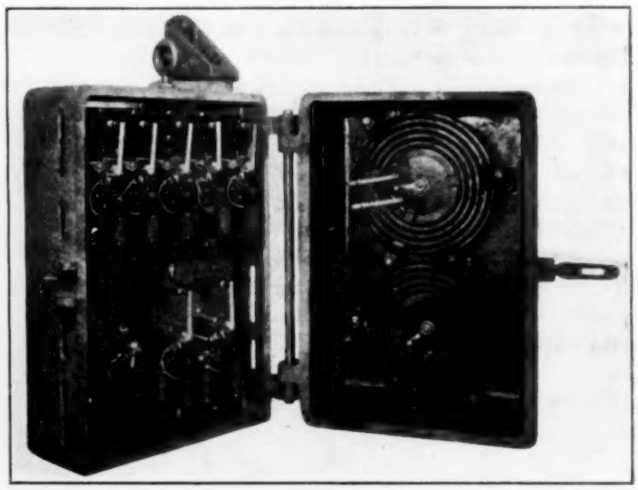

FIG. 11 PLANER CONTROL PANEL

Fig. 11 shows a 25 h.p. planer control panel. Fig. 12 shows a General Electric Co. 500 h.p., 250/1000 r.p.m., 230 volt reversing motor direct-connected to a Pond 36-in. by 20-ft. heavy pattern frog and switch planer.

Fig. 13 shows a diagram of connections of a planer control equipment, 10 to 25 h.p. Contactor No. 6 is the accelerating contactor. Contactor No. 8 is 2nd point dynamic brake, operated by the field current. When contactor No. 6 is open, field current is made through an auxiliary contact which short circuits the field rheostats and half of coil on No. 8 contactor. When field current approaches full field value, No. 8 contactor is so adjusted as to close.

At full field on the motor, which is the slowest speed, No. 8 contactor will close almost instantly, while on weak field (high speed) the contactor does not operate until such time as the field current has reached a predetermined value. This gives a definite time lag between closing of 1st point dynamic contactor (No. 4) and 2nd point (No. 8), which allows the motor field to be strengthened before increasing the dynamic brake load. When motor is accelerating contactor No. 6 closes, thus opening the auxiliary contact and allowing the field current to pass through the field rheostats and both sections of coil on contactor No. 8. The two sections of this coil are wound in opposite directions and the field current passing through both sections de-energizes the contactor and it opens.

For emergency stopping, when the circuit breaker opens, an auxiliary contact on the circuit breaker connects the motor field to the armature, and the armature is connected across the resistance for dynamic braking.

To meet conditions of load where the full load cut is necessary up to the end of the stroke, a definite brake value on cutting speed is maintained independent of return speed. This is accomplished by contactor No. 7, which has two half coils, one being connected across the line and one across the armature and either coil being powerful enough to operate the contactor. When the motor is running in the cutting direction, the coil across the line is in the same direction as the coil across the armature, so that the contactor operates and short circuits a part of the dynamic brake resistance, which can be adjusted to give a definite dynamic brake value on the cutting stroke. When the motor is running in the return direction, the coil across the armature is opposed to the coil across the line, and the contactor is inoperative until such time as the armature voltage has dropped to a predetermined value and the armature has decelerated to a definite speed on dynamic braking; the coil across the line then overpowers the coil across the armature and the contactor closes, giving a 3d point dynamic braking on return stroke.

With the above arrangement, the maximum variation of cutting stroke between no-load and full load at high speed is about 1 in. and is practically zero at the slow speed.

The complete electrical equipment for planer drive consists of a reversing adjustable speed motor; a contactor panel and enclosing case with the field rheostats mounted inside of the cover, with external operating handles; the starting and dynamic braking resistance; a master controller of the drum type; a pendant switch for emergency operation, a snap switch and a special circuit breaker. A drum controller is used for controlling the cross rail motor. It is proposed to make the control equipment of the smaller horsepower sizes self-contained to economize space and reduce the external wiring to be supplied by the user. An average time efficiency of 90 per cent (depending upon the speeds and cuts employed) is obtained with these equipments.

MOTORS

Not the least important factor for a successfully operating electrically controlled machine is the motor.

In a shunt motor which starts under constant field excitation, the torque is directly proportional to the armature current. This type of motor is applicable for machinery where constant speed is desired, as small printing presses, ventilating fans, small machine tools, woodworking machines, etc. For adjustable speed work it is applicable to planers, boring mills, heavy lathes, etc.

In a series motor, the field excitation will vary with the load, which results in a varying speed and a very powerful torque at slow speed. This type of motor should always have a certain friction load and be geared or direct connected to the load in order to avoid the possibility of the latter being thrown off and the motor accelerating to a dangerous speed. The type is applicable to centrifugal pumps, cranes and hoists.

In a compound motor, the combination of the shunt and series field produces the heavy starting torque with small variation in speed. The working speed can also be increased by means of the shunt field. This type of motor is applicable to machinery requiring large overload capacity for short periods of time, as rock crushers, air compressors, shears, large printing presses, etc.

While the control apparatus for general use must be designed to operate with a standard motor, it is necessary that the designers of both the motor and control appliances be in thorough coöperation—especially if the customer is to obtain satisfactory results. One of the main points to bear in mind in the application of electric control to shop tools is simplicity, not only in the design of appliances but in the control schemes as well. This is especially true in the application to special and heavy duty machines. This will mean that in many instances the motor will need to be designed for the purpose and have the desired characteristics as to stability, overload, commutation, etc. The control problem will then be very much simplified. Indeed, many of the troubles and probable failures of electric control in the past may have been due to the complicated control applied in an attempt to have the motor perform functions of which its design would not permit.

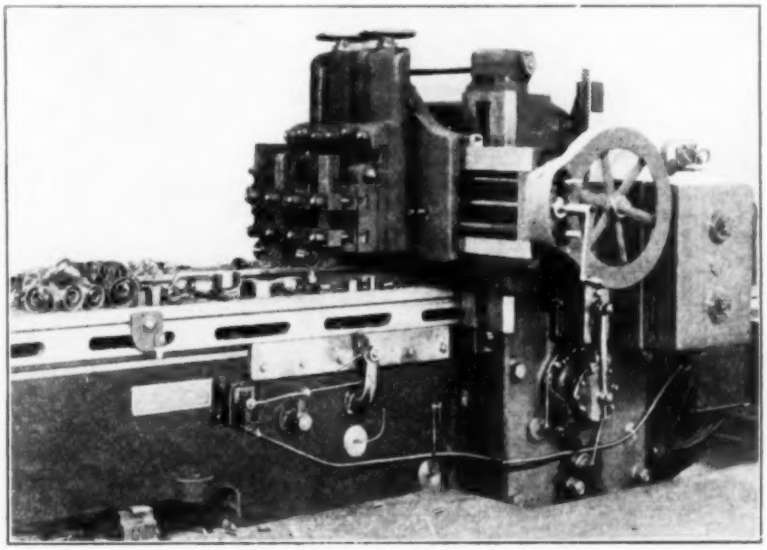

Fig. 12 Planer with Reversing Motor

DISCUSSION

H. D. James[1] (written). For starters for adjustable speed motors, the author specifies a field accelerating relay. The function of this relay is to prevent the operator from weakening the shunt field of the motor too rapidly during acceleration. The weakening of the shunt field causes the motor to take an increased current, and the relay operates in the same manner as an ammeter. When the current increases to a fixed value the relay closes the contact and increases the field strength of the motor momentarily. When the current drops the relay opens again, and this alternating closing and opening holds the field strength of the motor at the proper value during acceleration. The operation in this respect is ideal, and the relay has filled a long-felt want in many types of controllers. It has been found, however, that when the motor is operating at a high speed and the field rheostat is turned in the direction of reducing the motor speed, this increase in field strength causes the motor to act as a generator and return current to the line. This regenerative action may be very severe if the change in field strength is great. Under these circumstances the heavy current which flows causes the field relay to close the current, and still further strengthen the shunt field of the motor, causing an increased current flow. The opera-

[1] Box 3, East Pittsburgh, Pa.

tion of the relay in this respect is the opposite to what would be required for holding the current at its proper value.

The detrimental action of the field relay causes sufficient harm to more than counterbalance its good effects during acceleration, and better results can be obtained by omitting this field relay and using another device for strengthening the motor field during acceleration.

The author states that motors below 25 h.p. should have fuses for overload protection. The company with which I am connected is in favor of using overload relays on all sizes

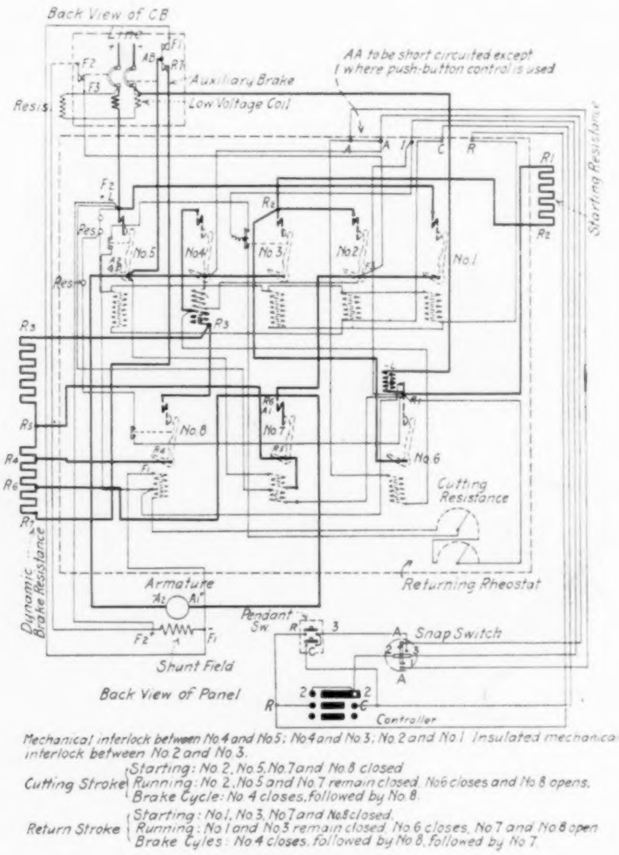

Fig. 13 Planer Control Contactor Connections

of motors, even down to 5 h.p., where such a relay can be adapted to the controller specified. The first cost of the relay is more than the fuse, but the continual replacing of fuses is a running expense and may often amount to more than the cost of the relay during the first year of operation. If fuses continue to open, there is a tendency to put in heavier ones, which is a further objection. Where an overload relay is used, it is so easy to reset the relay that very little annoyance is caused, and usually the calibration of the relay is left at a reasonable value.

The author states that a graduated dynamic breaking of two or more points is necessary on planers and boring mills. Tests made with the G. E. graphic recording ammeter on planer equipments at the William Wharton Shops, Jenkintown, Pa., showed that the retardation of the planer bed was so rapid during dynamic breaking that the ammeter recorded little or no difference between a single step dynamic braking and a graduated dynamic braking. These tests were made on Westinghouse, General Electric and Allis-Chalmers equipments; the G. E. equipment was of 50 h.p. size, and the others were 35 h.p. size.

In order to further analyze this condition we made oscillograph tests on 7½, 15 and 25 h.p. motors, both variable and constant speed, and with different maximum speeds and voltages. It was found that the graduated dynamic braking made practically no difference at the time of stopping, and merely added to the complication, the cost and the size of the control equipments. It is further found that a considerable variation can be made in the amount of resistance used in the dynamic braking circuit without affecting materially the time of stopping the motor. This investigation, which covers a period of over two years, has led us to abandon the graduated dynamic braking except in special cases where a considerable inertia load is stopped and the time of stopping is extended over a considerable period. The writer would be very glad to know of other tests made in this direction and what results they show. It is important to reduce controllers to a minimum number of parts, and no refinements which do not pay for themselves in actual results obtained should be introduced.

The safe temperature rise for any apparatus should be fixed by the materials entering into its design. The author states that the temperature rise on contacts and coils should not exceed 65 deg. under continuous operating conditions. This is high for some classes of apparatus and low for others. Recent improvements in insulation show that magnet windings can be operated at 125 deg. cent. actual temperature measured by resistance, and give good service over a long period of time. This comes under Class B insulation in the A.I.E.E. rules. The temperature of contacts is fixed by the fusing point of the material used; if a spring, by the temperature which draws the temper of the spring. The contacts subject to arcing, such as a line switch contactor, should be made of very refractory material, as the temperature set up in the contact on repeated operations is far in excess of any temperature which the contact may be subjected to by the passage of the current itself.

In criticism of Table 1, drum controllers we have had on the market for about ten years, having one step of starting resistance up to and including 15 h.p., and two steps of starting resistance above 15 h.p., and including 35 h.p., have proven very satisfactory. Further, we conducted a series of oscillograph tests extending over a period of six months on several hundred different motors, and we have adopted as our standard one step of starting resistance for motors up to and including 15 h.p. and two steps of resistance above 15 h.p. and including 25 h.p. Above that, we determine the number of steps by the motor used and the service conditions. Most machine tool motors start up light, as it is not the practice to start a machine tool with the tool cutting material. The resistance, however, is sufficient to start the motor under full load if the occasion should arise. In the above statement, by the resistance is meant that determined by dividing the volts by the amperes and adding sufficient external resistance to make the theoretical starting current of the proper value. As a matter of fact the self induction of the motor reduces the current at starting considerably below this value, particularly when the motor starts up at less than full load. This reduction in the number of starting notches reduces the size and cost of the controller, and if the control is rugged enough to stand the service it does not materially increase the wear on the resistance contactors. There are some types of control in which the switches used for short circuiting the starting resistance are light, and a larger number may be required in order to protect the switches.

In conclusion, it may be stated that the electrical equipment for both motor and controller is being reduced in complication

and gives increased durability. For the best conditions to obtain, the controller should be selected with respect to the motor used, as some designs and types of motor require more refinement in control apparatus than others. It is the business of the electrical manufacturer to offer to the machine tool builder a complete electrical equipment having a maximum durability and a minimum complication.

The writer heartily agrees with the general statements made by the author with reference to the advisability of using electric drive for machine tools. A great deal of engineering work has been done and investigations made in connection with drives of this kind, and it is now universally recognized that the individual motor represents the best practice in this respect.

A difficulty now encountered in motor application is the mechanical one of attaching the motor and controller to the machine tool so that it makes a presentable appearance. This difficulty is being overcome by the manufacturers of electrical apparatus adapting their designs to this service and by the machine tool designers obtaining a better conception of the electric drive requirements. A great deal can be done by still closer coöperation between the designers of both classes of machinery.

The writer believes in standardizing the requirements as much as possible. There is always danger that a rigid specification made may hamper development in the art. It is better to standardize first on general requirements only, and allow the manufacturers of electrical apparatus as much leeway as possible in working out the details of their part of the equipment. The apparatus described in this paper is a good representation of controllers manufactured by one of the leading companies, and in the main is representative of the art.

H. F. Stratton presented a written discussion in which he analyzed in some detail the electrical features of the paper, and in which was included the following paragraphs:

Some six or seven years ago the series accelerating switch was discovered, and its obvious cheapness and simplicity at once suggested that the time had arrived for applying, in a broad way, automatic control to motor-driven machine tools. Accordingly, about five years ago, a controller was designed and built which included a train of series accelerating switches, and an operator's switch, by means of which the motor could automatically be started, reversed, or stopped by dynamic braking. This controller, in substantially its original form, has come into extensive use, and to-day there are thousands of them operating successfully on a large variety of machine tools.

The purpose of the automatic machine tool controller is simple and important—it is to increase production. In this paper the author paints a word picture of a man manipulating a drum type or a dial type hand starter, and from this picture as a base, he passes on to the advantages of automatic control. I agree that the automatic controller possesses the advantages mentioned but am eager to put more emphasis on the main issue. What we are after is to keep the machine going the maximum amount of time and at maximum speed. Other seeming advantages are so in reality only when they yield tribute to this principle of increased capacity. It is true that automatic control protects the motor, but that is important chiefly because it saves delays; automatic control provides stopping by dynamic braking, but that too is important chiefly because unproductive time is transmuted into productive effort; it is true that the workman is relieved of much mental and physical effort, but that is important chiefly because he does more work. The problem is a matter of manufacturing economics rather than engineering technique.

Mr. Brooks intimates that the automatic controller is not satisfactory for lathes and he states that for many uses the drum controller has been found to fill the requirements quite satisfactorily. I think there are more automatic controllers on lathes than on all other machine tools combined. Several of the fastest working machine shops in this country are using several hundred such controllers. As long ago as 1913, the R. K. LeBlonde Machine Tool Co. wrote a letter containing this statement: "From recent tests made in our shop on one of our heavy duty lathes, equipped with your controlling devices, we find that we are able to produce 20 per cent more work than can be done on an ordinary motor driven lathe. These results are directly due to the automatic stopping, starting, and drift positions, and dynamic braking obtained by the use of your controlling devices."

I think the old style drum controller for lathes is unsatisfactory. In a recent paper by D. M. Petty, Electrical Engineer of the Bethlehem Steel Company, are described comparative tests made on duplicate engine lathes doing the same work and driven by duplicate controllers, the difference being an automatic controller in one case and a drum type controller in the other. Among other features is mentioned that the stopping time with the automatic controller using dynamic braking in the off point, was 8 sec. as against 40 sec. with the drum type controller. Mr. Petty draws the following conclusions:

First. The automatic controller protects the motor from not only excessive currents in starting, but excessive voltages in stopping.

Second. It decreases the starting and stopping time, which would amount to a considerable item when the operation requires frequent stopping.

Note. The possible exceptions to this conclusion would be that a drum type controller might equal the automatic on applications using speed adjustments of 1 to $1\frac{1}{2}$ or under.

To Mr. Petty's conclusion I would add the following points: First, the drum type controller has the damaging "pump back" characteristic which Mr. Brooks condemns, and second, with the drum type controller it is necessary to hunt for the desired speed each time the motor is stopped and started, whereas with an automatic controller this best cutting speed is maintained regardless of stopping and starting, until it is purposely changed to suit the changing requirements of the work. The only advantage which the drum controller enjoys over the automatic controller as applied to lathes, is that it requires but one spline shaft for apron control, whereas two are required for automatic control on very long bed lathes.

Under the subject of car wheel lathes it is stated that the controller panel should include in addition to accelerating contactors, two dynamic braking contactors. Why not use the same contactors for acceleration and dynamic braking, as this is easily accomplished?

Mr. Brooks says a reversing planer controller should incorporate dynamic braking. It is my belief that the planer motor should be reversed by the reverse power method instead of being first stopped by dynamic braking and then reversed. The point is to reverse the motor in the quickest safe time. The quickest reversal is accomplished by having field strength at its maximum, armature current of its highest safe value, and a minimum number of movements of magnetically operated switches. To first stop the motor by dynamic braking,

means that dynamic braking switches must close and open, and in addition the reversing switches must function.

C. D. KNIGHT. The trend of the discussion seems to be regarding the relative merits of the drum controller vs. the automatic, and also the use of automatic control on lathes.

The drum controller has been in successful use for a great many years, and by many is considered an exceedingly efficient piece of apparatus. Mr. Brooks in specifying the advantage of automatic control states that a considerable increase in the output of the machine is obtained, and there is no doubt but what in a great number of cases this is so. It stands to reason that a man cannot operate the drum controller throughout the whole day as rapidly as he can the automatic.

Furthermore, with automatic control the motor comes up to the same predetermined speed each time. With the drum controller, especially with adjustable speed motors, the operator is liable to obtain various speeds at different times on the same class of work, due to his not bringing the drum controller handle to the same point on each cycle of operation. With automatic control, including field relays, once the field rheostat is set for a certain speed it is absolutely certain that the motor will accelerate to that speed each time.

Another great advantage of automatic control is the question of insuring safety to the operator. By placing push buttons or small enclosed master switches on the machine, the main part of the controller can be mounted away from the machine, and whether open or enclosed, it will be out of the reach of the operator. I certainly believe that in following the lines of Safety First, we will in time have totally enclosed motor controlling apparatus.

Regarding the question of lathe control, there is no doubt but what a great many machines have been successfully equipped with automatic devices. Where the lathe is small and the speed regulating device can be placed on the headstock of the lathe within the reach of the operator, it is safe to say the problem can and has been fairly well solved. The problems I have in mind are on big lathes where the operator may be 10 or 15 feet away from the headstock of the lathe. In this case it is necessary to have the speed regulating device controlled from the apron of the lathe. There have been many proposed methods of doing this, but I have yet to see anything which looks like a successful solution of the problem.

H. K. HATHAWAY. The discussion of the possibilities of electrical control on milling machines, drill presses and machines of that character, which are not in the class of automatic machines in the same sense that automatic screw machines are, should open up a very fertile field. There is much to be done in the way of developing mechanism for the starting and reversing of milling machines after the cutting has been done, for the releasing of clamping devices, etc. This is a subject which our Local Sections might very well discuss further.

H. J. EBERHARDT. A few years ago, at the Newark Gear Cutting Machine Company, we adapted a standard motor and starting device to one of our standard machines. The problem came up of how to stop the motor when the function of the machine had reached its limit. One way was to put a switch breaking mechanism, operated by a heavy spring, against the main switch and throw it out bodily, with the danger of an arc forming; but what we did was to utilize the overload switch, by putting a small bell crank up against the overload armature, and the pressure exerted by a fibre button, on the end of the bell crank, threw the overload switch and stopped the motor.

RALPH E. FLANDERS. Regarding the statement of Professor Goss, included in the paper, that in the machine tool of the future we shall not see belts, I am aware that up-to-date electrical controlling apparatus is provided with current overload, coils and switches; but there is nothing like a slipping belt for telling a shop man that there is something wrong with the machine. The very best safety device that I know of between the lineshaft or motor and the machine is a properly proportioned belt, and I wish to put in a word for the belt as a prominent feature of modern design.

ELMER H. NEFF. My attention has been attracted to the quotation from Professor Goss' address. I fear the interpretation placed on the quotation is hardly correct because a machine in which there should be no pulleys, belts or gears would surely be something of a problem for a machine designer to produce. Mr. Flanders has spoken a word for the pulleys and belts, and I wish to put in a word for the gears. I am in favor of all machine tool transmission having absolutely positive connections for the main drive and for the feed, and of tying up the feed drive with the main drive so that it cannot work unless the main drive is in satisfactory operation.

At the Milwaukee meeting of this Society in 1901, one session was devoted to the subject of electrically driven machine tools. At that time an enthusiastic electrical advocate stated that in a short time practically all machine tools would be driven by electric motors. Nearly fifteen years have passed and yet today the proportion of machine tools sold fitted up with motors is relatively small. I am inclined to think that such extravagant statements as the above, and other similar statements which have been made by the advocates of electric drive, have done as much as anything else to hinder progress in that direction.

When electrically driven machine tools were first sold, the application of motors was made on machines that had not been designed with their use in view, consequently the arrangements were clumsy and cumbersome. The variations in speed had to be obtained by varying the speed of the motor or by adding to the machines themselves, between the work spindle and the motor, additional apparatus for obtaining the speed variations. This made the motor drive a very expensive one to obtain for two reasons. If the variable speed was obtained by varying the speed of the motor, the motor had to be much too large for ordinary purposes because at the slowest speed the maximum power was required. If mechanical means for changing the speed were supplied, a relatively large expense was involved.

A very fine thing has come out of this agitation for motor driven machines in that machine tools have been redesigned so that it is relatively easy to substitute a motor with sprockets and chains for the belt connection, all the speed changes being regularly incorporated in the machines themselves. These machines which are called single belt drive machines, or constant speed drive machines, furnish the best solution of the motor drive problem. A constant speed motor should be used, and by varying the speed mechanically within the machines you have the maximum rotative effect at the slow spindle speed which is the time at which you want it most. A further advantage has been that, by driving the feed works of the machine from the constant speed main drive shaft, it is possible to vary the spindle speed without changing the rate of feed, consequently any feed can be obtained with any spindle speed, and the most advantageous spindle speeds and the most advantageous feeds can be used on the work in hand. The machine thus designed, which as I have stated especially lends

itself to the application of a motor, has equally great advantage when it is used as regularly intended, with a belt drive from the overhead works. With a friction pulley on the machine for the application of power, and when the machines are designed, as they are in many cases, with the possibility of reversing the direction of rotation of the spindle by the mechanism in the machine itself, it is possible to drive these machines without the use of a countershaft, by belting directly from the line shaft to the machine.

For light machine tools I am an advocate of the group drive system rather than the individual drive. By light machine tools I refer to those requiring a 3 h.p. motor or smaller. A great multiplicity of motors such as involved by the individual motor drive involves too much expense for installation; too much expense for up-keep and attention; too much lost power. The group drive system in which a motor can be applied to a line shaft or to the machines in a particular room furnishes, I believe, the ideal electrical arrangement for light machine tools. In such cases the motors can be of sufficient size to run economically and all of the objections which I have stated with regard to the individual drive are eliminated. For large machines, or for isolated machines whether large or small, the individual motor drive furnishes a neat and desirable arrangement.

The Author. It will be noted that the paper contemplates the permanent short circuit of the field rheostat during acceleration, and, as Mr. James states, the operation of the field accelerating relay, with proper rheostat connections, is ideal for adjustable speed motors.

Referring to the use of overload relay vs. fuses, there are, of course, personal opinions as to where the dividing line should be. This point, of course, comes up in connection with the operation of a single step starting resistance which was advocated up to 15 h.p., as the peak current during acceleration under these conditions would be considerably over 200 per cent normal current, and unless the overload relay were fitted with a time limit device, there would not be sufficient protection to the motor during normal working conditions. It will also be noted that the oscillograph tests which our company have made indicate that there is no difference in the peak current, whether the motor starts with a no-load or full-load, the main question being whether or not the motor will stand the service.

In connection with the question of dynamic braking, the opinion seems to be universal as to the necessity for this, the difference being in the method in which it is applied, and it would appear that planers and boring mills especially, where graduated dynamic braking is recommended, would come under Mr. James' classification of heavy inertia loads. The question also arises that if graduated braking is required on heavy inertia loads, why is it not also desirable in other cases? It is very easily proven mathematically that increased torque obtained by dynamic braking of necessity gives decreased stopping time, assuming that the dynamic brake resistance is properly adjusted to the operating conditions of load.

The 65 deg. temperature rise recommended on contactor coils is in accordance with A.I.E.E. rules and U. S. Government standards for this type of appliance. At the present time the use of Class B insulation for contactor coils is not general practice, although it is a probability for the near future.

In the paper and by various members in the discussion, the necessity for coöperation between the machine tool builders and the electrical manufacturers is very forcibly emphasized.

SAFETY CODE FOR THE USE AND CARE OF ABRASIVE WHEELS

This Code was originally prepared by the Abrasive Wheel Manufacturers. It was presented to the Society, who referred it to the Committee on Machine Shop Practice. This committee carefully reviewed it, made some suggestions involving slight modifications and approved it.

SAFETY DEVICES

Three general types of safety devices to be used for grinding wheels, namely: protection flanges, protection hoods and protection chucks, are recommended.

ARTICLE A: PROTECTION FLANGES

A1 Protection flanges of the double or single concave type, used in conjunction with wheels having double or single convex tapered sides or side, are recommended.

A2 Flanges of the sizes shown opposite wheel diameters in column C, article A9, shall be used. As wheels wear, size of flanges, as indicated in column C, article A9, shall be maintained.

A3 New installations of protection flanges for double tapered wheels shall have a taper of not less than three-quarters (3/4) of an inch to the foot for each flange, and the center of flange shall conform with the dimensions shown in column B, article A9. Such flanges shall be of a thickness not less than is shown in column D, article A9.

A4 New installations of protection flanges for single tapered wheels shall have a taper of not less than three-quarters (3/4) of an inch to the foot, and the center of flange shall conform with dimensions shown in column B, article A9. Thickness of such flanges shall be as shown in column F, article A9.

A5 Each flange, whether straight or tapered, shall be relieved or recessed at the center at least one-sixteenth (1/16) of an inch on the side next to the wheel for a distance as specified in column E, article A9.

A6 All tapered flanges over six (6) inches in diameter shall be of steel, or other material of equal strength. Tapered flanges six (6) inches and smaller in diameter may be made of cast iron.

A7 All flanges shall be accurately turned, correct to dimensions and in balance, except flanges which are purposely made out of balance. Two such are known as balancing flanges and are sometimes used to counteract out-of-balance condition in an abrasive wheel.

A8 Both flanges in contact with the wheels shall be of the same diameter.

A9 Dimensions in inches of tapered flanges and tapered wheels where hoods are not used in conjunction therewith, are given in Table 1.

ARTICLE B: PROTECTION HOODS

B1 Protection hoods shall always be used where practical with wheels not provided with protection flanges. Hoods shall be designed and constructed of a material sufficiently strong to retain all pieces of a broken grinding wheel.

B2 Hoods shall conform as nearly as possible to the periphery of the wheel, and shall be so designed as to leave exposed the least portion of the wheel compatible with the work, and shall be of the adjustable type or provided with a sliding tongue or similar device, or a method of contract-

Presented at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 1915. Pamphlet copies may be obtained: price 5 cents to members, 10 cents to non-members.

ing the rim, for the purpose of closing the opening in the hood as the wheel is reduced in diameter, to afford maximum protection at all times.

B3 Protection hoods must be securely fastened to the grinding machine. If advisable, hoods may also be fastened to the floor.

ARTICLE C: CUPS, CYLINDERS AND SECTIONAL RING WHEELS

C1 Cups, cylinders and sectional ring wheels shall be either protected with hoods, or enclosed in protection chucks, or surrounded with protection bands. Not more than one-quarter (¼) of the height of such grinding wheels shall protrude beyond the provided protection.

ARTICLE D: GENERAL SAFETY REQUIREMENTS

D1 Competent men shall be assigned to the mounting, care and inspection of grinding wheels and machines.

D2 Before mounting, all wheels shall be closely inspected to make sure that they have not been injured in transit, storage or otherwise. For added precaution, wheels other than of the elastic and vulcanite type should be tapped lightly with a hammer; if they do not ring with a clear tone they should not be used. Damp wheels when tapped with a hammer may not give a clear tone. Wheels must be dry and free from sawdust when applying this test.

TABLE 1 DIMENSIONS OF TAPERED FLANGES AND WHEELS

a Maximum flat spot at center of flange.
b Flat spot at center of wheel.
c Minimum diameter of flange.
d Minimum thickness of flange at bore.
e Minimum diameter of recess in taper flanges.
f Minimum thickness of each flange for single taper at bore.

Diam. of Wheel in In.	a	b	c	d	e	f
6	0	1	3	⅜	2	⅜
8	0	1	5	⅜	3½	⅜
10	0	2	6	½	4	½
12	4	4½	6	⅝	4	⅝
14	4	4½	8	⅝	5½	¾
16	4	6	10	⅝	7	⅞
18	4	6	12	¾	8	1
20	4	6	14	¾	9	1
22	4	6	16	¾	10½	1⅛
24	4	6	18	¾	12	1⅛
26	4	6	20	¾	13½	1⅛
28	4	6	22	⅞	14½	1¼
30	4	6	24	⅞	16	1¼

NOTE:—Where hoods are used in conjunction with tapered wheels and tapered flanges the specifications given in article D 12 may be followed.

D3 Grinding wheels shall fit freely on the spindles; they shall not be forced on, nor shall they be too loose.

D4 Wheel arbor holes shall be made 0.005 inches larger than the machine arbor.

D5 The soft metal bushing shall not extend beyond the sides of the wheel at the center.

D6 Minimum sizes of machine spindles in inches for various diameters and thicknesses of grinding wheels are given in Table 2.

D7 Ends of spindles shall be threaded left and right, so that the nuts on both ends will tend to tighten as the spindles revolve. Care should be taken in setting up machines that the spindles are arranged to revolve in the proper direction, else the nuts on the ends will loosen.

D8 Wheel spindles shall be of sufficient length to permit of the nut being drawn up at least flush with the end of the spindle, thus providing a bearing for the entire length of nut.

D8a Protruding ends of the wheel arbors and their nuts shall be guarded.

D9 The surfaces of wheels in contact with straight or tapered flanges, the surfaces of the flanges in contact with the wheels and the wheel washers between the flanges and wheel shall be clean, smooth and free from foreign material.

D10 Size of straight flanges for straight wheels shall not be less than shown by column B, section D12.

D11 All straight flanges shall be relieved or recessed at the center at least one-sixteenth ($^1/_{16}$) of an inch on the inside surface of flange for a diameter as specified in column C, article D12.

D12 Dimensions of straight flanges and straight wheels used with protection hoods are given in Table 3.

D13 Wheels shall never be run without flanges.

D14 Both flanges in contact with the wheels shall be of the same diameter whether straight or tapered.

D15 Wheel washers of compressible material, such as blotting paper, rubber or leather, not thicker than approximately 0.025 inches, shall be fitted between the wheel and its flanges. It is recommended that the wheel washers be slightly larger than the diameter of the flanges used.

D16 When tightening clamping nuts, care shall be taken to tighten same only enough to hold the wheel firmly, otherwise the clamping strain is apt to crack the wheels.

TABLE 2 MINIMUM SIZES OF MACHINE SPINDLES

Diam. in In.	Thickness of Wheel in In.																		
	¼	⅜	½	⅝	¾	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3¼	3½	4	4½	5
6	½	½	½	½	½	½	⅝	⅝	¾	¾	¾	¾	¾	¾	¾	¾	1	1	1
7	½	½	½	½	⅝	⅝	⅝	¾	¾	¾	¾	¾	¾	1	1	1	1	1	1
8	⅝	⅝	⅝	⅝	⅝	⅝	¾	¾	¾	1	1	1	1	1	1	1	1¼	1¼	1¼
9	⅝	⅝	⅝	⅝	¾	¾	¾	¾	1	1	1	1	1	1¼	1¼	1¼	1¼	1¼	1¼
10	¾	¾	¾	¾	¾	¾	¾	¾	1	1	1	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½
12	¾	¾	¾	¾	¾	1	1	1	1	1	1	1¼	1¼	1¼	1¼	1¼	1½	1½	1½
14	⅞	⅞	⅞	⅞	1	1	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½	1½	1½	1½	1½
16	..	..	..	..	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½	1½	1½	1½	1¾	1¾	1¾	1¾
18	..	..	..	..	1¼	1¼	1¼	1½	1½	1½	1½	1½	1½	1½	1¾	1¾	1¾	1⅞	1⅞
20	..	..	..	..	...	1½	1½	1½	1½	1½	1½	1½	1¾	1¾	1¾	1⅞	1⅞	1⅞	1⅞
24	..	..	..	..	...	1½	1½	1½	1¾	1¾	1¾	1¾	1¾	1¾	2	2	2	2	2
26	..	..	..	..	...	...	1½	1½	1¾	1¾	1¾	1¾	2	2	2	2	2¼	2¼	2¼
30	..	..	..	..	...	...	...	1¾	1¾	2	2	2	2	2	2¼	2¼	2½	2½	2½
36	..	..	..	..	...	...	...	...	2	2¼	2¼	2¼	2½	2½	2½	2¾	2¾	3	3

D17 Flanges, whether straight or tapered, must be frequently inspected to guard against the use of flanges which have become bent or sprung out of true, or out of balance. If a tapered wheel has broken, the tapered flanges must be carefully inspected for truth before using with a new wheel. Clamping nuts shall also be inspected.

D18 The work rest must be kept adjusted close to the wheel to prevent the work from being caught. Work rests must be rigid and always securely clamped after each adjustment.

D19 (1) A speed of 5000 peripheral feet per minute is recommended as the standard operating speed for vitrified and silicate straight wheels, tapered wheels and shapes other than those known as cup and cylinder wheels, which are used on bench, floor, swing frame and other machines for rough grinding. Speeds exceeding 5000 feet may be used upon recommendation of the wheel manufacturer but in no case shall a speed of 6500 peripheral feet per minute be exceeded. (2) A speed of 4500 peripheral feet per minute is recommended as standard operating speed for vitrified and silicate wheels of the cup and cylinder shape, used on bench, floor, swing frame and other machines for rough grinding. Speeds exceeding 4500 peripheral feet per minute may be used upon recommendation of the wheel manufacturer, but in no case shall 5500 peripheral feet per minute be exceeded.

D20 For elastic, vulcanite and wheels of other organic bonds, the recommendation of individual wheel manufacturers shall be followed.

D21 For precision grinding an operating speed of 6500 peripheral feet per minute may be recommended. Speeds higher than 6500 peripheral feet per minute can be used only upon recommendation of the wheel manufacturer.

D22 Table 4 gives revolutions per minute for various sizes of wheels for the peripheral velocities in feet per minute at the head of each column.

D23 Machine spindle speeds shall be tested and determined correct for size of wheel to be operated before wheel is mounted, and shall never be changed as a wheel is reduced in diameter, except by men assigned for such duties.

D24 If a wheel spindle is driven by a variable speed motor, speed control of the motor shall be enclosed in a locked case, or some device shall be used which prevents motor from being run at too high speeds.

D25 Grinding machines shall be sufficiently heavy and rigid to prevent vibration, and they should be securely mounted on substantial foundations.

TABLE 3 DIMENSIONS OF STRAIGHT FLANGES AND WHEELS

A	B	C	D
Diam. of Wheel in In.	Minimum Outside Diam. of Flange	Minimum Diam. of Recess	Minimum Thickness of Flange at Bore
6	2	1	⅜
8	3	2	⅜
10	3½	2¼	⅜
12	4	2¾	½
14	4½	3	½
16	5½	3½	½
18	6	4	⅝
20	7	4½	⅝
22	7½	5	⅝
24	8	5½	⅝
26	8½	6	⅝
28	10	7	¾
30	10	7	¾

D26 No user of wheels shall use on any given machine a wheel of larger diameter or greater thickness than specified by the machine builder.

D27 Wheels which wear out of round shall be trued by a man assigned to that duty. If wheels, not provided with balancing flanges, become out of balance through wear and cannot be balanced by truing or dressing, they should be removed from the machine.

D28 A wheel used in wet grinding shall not be allowed to stand partly immersed in the water. Water-soaked portion may throw the wheel dangerously out of balance.

D29 Wheel dressers should be equipped with rigid sheet metal or other guards over the tops of the cutters to protect operator from flying pieces of broken cutters.

D30 Goggles shall be provided for use of grinding wheel operators where there is danger of eye injury. They should be readily accessible, or better, should be the individual property of the operator.

D31 The space about the machine shall be kept dry, clean and as free as possible from castings or other obstructions.

D32 Grinding rooms shall not only be well ventilated and well lighted, but kept warm and dry. Machines used continuously for dry grinding shall be attached to a dust-exhausting system. Besides protection to the workmen, the dust-exhausting system prevents wear and tear on machinery and belts.

D33 Care shall be exercised in the storage of wheels. They shall be stored in dry places and should be well supported on edge in racks. Work shall not be forced against a cold wheel, but the work applied gradually, giving the wheel an opportunity to warm and thereby eliminate possible breakage. This applies to starting work in the morning in grinding rooms which are not heated in winter, and new wheels which have been stored in a cold place.

ARTICLE E: PRECAUTIONARY SUGGESTIONS

E1 Cone pulleys determining the speed of a wheel should never be used unless belt locking devices are provided.

E2 The maximum size of wheel which should be used with given operating speeds should be indicated on each machine.

TABLE 4 R.P.M. FOR VARIOUS SIZES OF GRINDING WHEELS

Diam. of Wheel in In.	Peripheral Speed					
	4,000	4,500	5,000	5,500	6,000	6,500
1	15,279	17,200	19,099	21,000	22,918	24,850
2	7,639	8,590	9,549	10,500	11,459	12,420
3	5,093	5,725	6,366	7,000	7,639	8,270
4	3,820	4,295	4,775	5,250	5,730	6,205
5	3,056	3,440	3,820	4,200	4,584	4,970
6	2,546	2,856	3,183	3,500	3,820	4,140
7	2,183	2,455	2,728	3,000	3,274	3,550
8	1,910	2,150	2,387	2,635	2,865	3,100
10	1,528	1,720	1,910	2,100	2,292	2,485
12	1,273	1,453	1,592	1,750	1,910	2,070
14	1,091	1,228	1,364	1,500	1,637	1,773
16	955	1,075	1,194	1,314	1,432	1,552
18	849	957	1,061	1,167	1,273	1,380
20	764	860	955	1,050	1,146	1,241
22	694	782	868	952	1,042	1,128
24	637	716	796	876	955	1,035
26	586	661	733	809	879	955
28	546	614	683	749	819	887
30	509	573	637	700	764	827
32	477	537	596	657	716	776
34	449	506	561	618	674	730
36	424	477	531	534	637	689
38	402	453	503	553	603	653
40	382	430	478	525	573	621
42	364	409	455	500	546	591
44	347	391	434	477	521	564
46	332	374	415	456	498	539
48	318	358	397	438	477	517
50	306	344	383	420	459	497
52	294	331	369	404	441	487
54	283	318	354	389	425	459
56	273	307	341	366	410	443
58	264	296	330	354	396	428
60	255	277	319	350	383	414

E3 Grinding machines should be provided with a stop or some method of fixing the maximum size of wheel which may be used, at the speed at which the wheel spindle is running.

E4 Boxes must be of proper length to provide an ample bearing surface, and prevent heating or rapid wear. It is important that the bearings be kept well lubricated and properly adjusted. Ring oiling devices are recommended, amply protected from dust and grit, and box caps should be adjustable for take-up.

E5 For protection against flying chips, etc., plate glass in metal frames can be placed just above the grinding spaces of the wheels.

E6 Where it is impracticable or undesirable to use a glass shield, a leather flap may be attached to the hood and adjusted so as to interrupt sparks and dust.

E7 Table 5 of causes of grinding wheel accidents has been prepared by the Independence Inspection Bureau, and by their courtesy it is published with this report.

TABLE 5 CAUSES OF GRINDING-WHEEL ACCIDENTS. (Prepared by the Independence Inspection Bureau of Philadelphia for general distribution.)

- **Broken wheels (caused by)**
  - Cracked wheel (caused by)
    - Improper inspection of wheel
      - Before issued to operator.
      - When being mounted.
    - Dropping or striking against some object while not being operated
      - During storage; While being mounted; While standing
        - Carelessness.
        - Horseplay.
    - Being forced on improper sized spindle
      - Too small bushing.
      - Too large spindle.
    - Heated spindle
      - Tight bearings
        - Lack of oil.
        - Improper spindle size.
      - Inner flange not fixed on spindle.
    - Only one flange
      - Careless mounting.
      - Ignorance.
    - Uneven bearing of flanges
      - Bent or broken flange or flanges; Bushings projecting beyond sides of wheels; High spots on flanges; High spots on wheels
        - Improper specifications.
        - Ignorance.
    - Flanges of different diameters
      - Careless Mounting.
      - Ignorance.
    - Flanges not properly relieved
      - Entirely without relief; Diameter of relief too small
        - Improper specifications.
        - Ignorance.
    - Compressible washers
      - Missing; Too thin; Too small diameter
        - Carelessness.
        - Ignorance.
    - Tightening of nut
      - Carelessness.
      - Ignorance of mounter.
    - Hacking of wheel
      - Desire for increased cutting.
      - No restriction on use of wheel.
    - Screwing wheel on taper arbor
      - Ignorance.
  - Too high rim speed (caused by)
    - Spindle overspeeded
      - Overspeed when first set up.
      - Speed increased
        - Desire for increased cutting.
        - Thoughtlessly increasing speed of line shaft.
      - Use of cone pulley
        - Shifting to small pulley
          - Desire for increased cutting.
          - Loose shifter.
          - Carelessness.
    - Use of too large wheel for spindle speed
      - Wheel initially too large
        - Carelessness.
        - Ignorance.
      - Too large wheel substituted
        - Desire for increased cutting.
        - Ignorance or indifference.
      - Wheel of different grain and lower recommended speed substituted; Wheel of different shape substituted; Wet wheel substituted
        - Ignorance or indifference.
  - Catching work between rest and wheel (caused by)
    - Improper adjustment of rest
      - Lack of attention.
      - Ignorance.
    - Improper handling of work
      - Side grinding when rest not designed for it.
      - Pushing work under rest — Ignorance.
  - Out of true (caused by)
    - Loose bearings
      - Lack of attention.
      - Ignorance.
    - Bent spindle
      - Lack of attention.
      - Ignorance.
    - Loose frame
      - Lack of attention.
      - Ignorance.
    - Rough or improper use
      - Inexperienced men.
      - Responsibility of foreman.
- **Broken wheels (caused by)**
  - Unbalanced wheel (caused by)
    - Wheel standing in water (see under "cracked wheel").
    - Side grinding (see below).
    - Wheel untrue.
  - Weakened wheel (caused by)
    - Wheel standing in water (see above).
    - Side grinding (see below).
    - Hacking wheel (see above).
  - Too small spindle (caused by)
    - Bushing too small in wheel; Wrong spindle used for size of wheel
      - Ignorance or indifference.
  - Side grinding on improper wheel (caused by)
    - Lack of proper equipment.
    - Inexperience of men.
    - Indifference.
- **Flying wheel unbroken (caused by)**
  - Mounted so that nut works loose (caused by)
    - Spindle threaded in wrong direction — Improper specifications.
    - Belt twisted so that machine runs opposite to initial direction — Equipment incorrectly erected.
    - Motor reversed; Spindle turned end for end
      - Ignorance.
- **Work or dresser hurled out of workman's hand (caused by)**
  - Caught between rest and wheel
    - See above.
- **Flying particles of emery, inhaled or in eye (caused by)**
  - Exhauster defective (caused by)
    - Entire lack of exhauster
      - Exhauster not provided.
      - Exhauster disconnected.
    - Exhauster line not proper size
      - Ignorance.
      - Desire for saving expense.
    - Exhauster line stopped up
      - Not often cleaned.
      - Poorly designed or constructed.
  - Eye protection insufficient (caused by)
    - No goggles provided.
    - Improper goggles provided.
    - Goggles not used
      - Prejudice.
      - Carelessness.
      - Fear of infection.
  - Chip guard defective (caused by)
    - No chip guard.
    - Chip guard not in use
      - Broken and not replaced.
      - Prejudice of workmen.
- **Flying pieces of broken revolving type of dresser (caused by)**
  - No guard for dresser.

OPERATION OF PARALLEL AND RADIAL AXLES OF A LOCOMOTIVE BY A SINGLE SET OF CYLINDERS

BY ANATOLE MALLET, PARIS, FRANCE

Honorary Member of the Society

AN examination of the principal arrangements proposed for transmitting power to convergent axles without, however, increasing the number of steam cylinders, forms the subject of the present paper. These various systems of transmission may be divided into two classes: *First*, those which involve elements having rotary motion; *second*, those which involve elements having reciprocating motion.

TRANSMISSION BY ROTARY MOTION

This class includes gear transmission, transmission by endless chain and transmission by universal joints.

Gear Transmissions. Although the first use of gear transmissions dates back to the very origin of locomotives, they appear to have been first utilized for operating locomotive axles having freedom of radial movement in 1838, in a locomotive built at Heath Abbey for the Rhymney foundry in Wales. This locomotive was carried on two trucks with two axles each. The two trucks could turn so that they were at an angle with each other without throwing the driving gears out of mesh.

In 1841, the Baldwin Locomotive Works built a locomotive in which the rear axles were driven by means of a countershaft and connecting rods, and the axles of the front truck were operated by a gear transmission located on the longitudinal axis of the machine. This locomotive weighed $13\frac{1}{2}$ tons and was designed for use on a quarry railroad, but the type was afterward abandoned.

The French engineer, Tourasse, presented at the Competition of Semmering in 1851 a design of locomotive with six axles, similar to the Rhymney locomotive. It may be seen from Fig. 1 that from the cylinders is operated a countershaft carrying a toothed gear which engages with toothed wheels carried on the nearest axle of each track, these axles in turn being coupled to the other axles by outside connecting rods. This locomotive was to weigh 60 tons with the water carried in a saddle tank on the boiler. The cylinders were 0.50 m. (1.64 ft.) in diameter with a 0.60 m. (1.97 ft.) stroke; the wheels were 1.20 m. (3.93 ft.) in diameter and the heating surface, 250 sq. m. (2590 sq. ft.). The power developed would have been extraordinarily large for that time, since, according to the author of the design, the locomotive was to be able to start with a load of 250 tons over a grade of $2\frac{1}{2}$ per cent, although a capacity of only 140 tons was required.

The Locomotive Works of Winterthur, Switzerland, built in 1883, for an industrial railroad in the south of France, a locomotive similar to the one just described. It was supported on two trucks of two axles each, and weighed 22 tons. It appears that this type was unsuccessful.

The famous Engerth locomotive (Fig. 2), built after the Semmering Competition from which no practical results were obtained, was at first characterized by the use of gear transmission for connecting the last axle of the locomotive to the forward axle of the tender. The intermediate shaft, carrying the middle toothed gear, is arranged to slide longitudinally in its bearings if necessary, to cut out the connection with the wheels of the tender.

Quite a large number of Engerth locomotives were built. As a rule, they had six driving wheels under the locomotive proper and four under the tender, or a total of ten in all. As the gears did not give satisfactory results in actual practice, however, they were eliminated and the machine reduced to the type of locomotive and tender with six coupled wheels. The complicated gear transmission type has long since entirely disappeared from practice.

Within recent years, a locomotive builder in Lyons has built some small narrow gage locomotives which are supported on four axles—all driving. The three rear axles are coupled by external connecting rods, while the front axle, which has radial freedom of motion, is connected with the axle next to it by a train of gear wheels located in the longitudinal axis of the machine, just as in the Engerth type. It does not appear, however, that this system has found an extensive application.

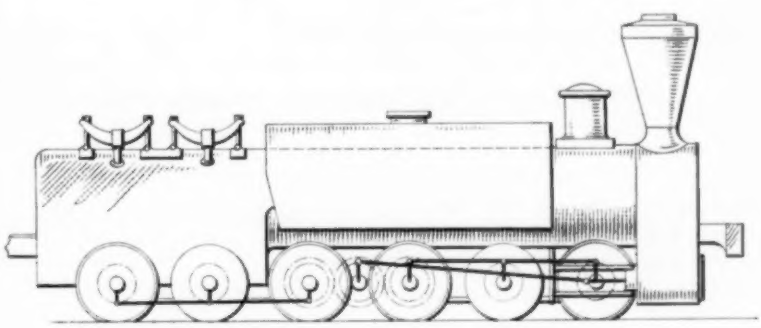

FIG. 1 SIX-AXLE GEAR TRANSMISSION LOCOMOTIVE BY TOURASSE

Before 1830, W. N. James, of Birmingham, proposed to connect not only the axles of the locomotive and tender but also those of the cars by means of gear wheels operated by a longitudinal shaft running the length of the train and provided with ball and socket joints to give them the flexibility necessary for making the curves. By this arrangement the inventor proposed to obtain sufficient adhesion to handle the train on grades without recourse to the Blenkinsop rack, and he stated that experiments made on a small scale showed that he could make grades of three inches in a yard, or 1 in 12.

There are, in actual use in the United States, locomotives in which the axles of the engine and of the tender are coupled together by gears and a longitudinal shaft fitted with ball sockets. These locomotives are of the Climax, Shay and Heisler systems, which differ from one another in the arrangement of the details of transmission and the location of the steam cylinders. These systems are too well known to necessitate their description here, but it may be of interest to state that they have been used even for very large units. Thus, the Climax and Heisler locomotives have actually been built in sizes of 75 to 80 tons and the Shay locomotives, up to 135 tons.

Transmission by Endless Chain. The use of endless chain for coupling axles which may be thrown out of parallelism appears to have been adopted for the first time in 1851, by S. A. Maffei, of Munich, in the construction of the locomotive Bavaria, presented by him at the Semmering Competition. This machine (Fig. 3) had seven axles, driven by two cylinders The axles were divided into three groups and the wheels of each group were coupled by external connecting rods, while

Presented at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 1915. Pamphlet copies without discussion may be obtained; price 10 cents to members; 20 cents to non-members.

the groups were connected by endless chains made of links and studs. The engine weighed 68,000 kg. (74.8 tons) with its equipment and it was given the first prize at the Competition after having satisfactorily passed all the tests. It was said that the victory was due only to the very brief duration of the tests, and that this locomotive could be maintained in good operating condition only by constant repairs to the chain transmissions. As a matter of fact, the Bavaria has never been reproduced in full or in part.

The Locomotive Works of Winterthur built a locomotive with three axles, the middle one rigid and the two others with

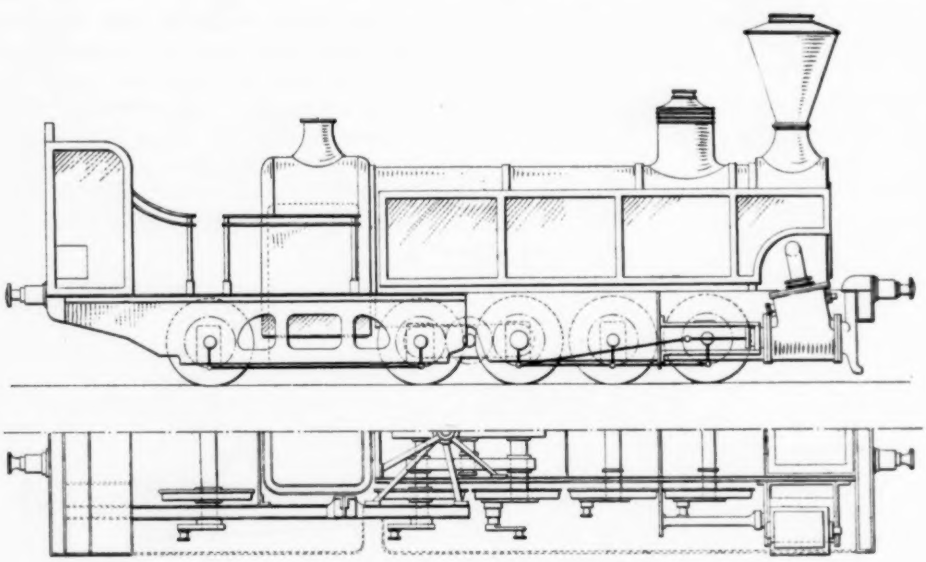

FIG. 2 ORIGINAL ENGERTH LOCOMOTIVE

radial displacement. The two non-rigid axles were connected by Galle chains[1] engaging with rim gear sprockets attached to the axle by ball sockets. The cylinders were located forward, were vertical and drove a countershaft which was coupled with the axles by the Galle chains. The locomotives of standard gage were 16.5 tons and could handle curves of 11 m. (36.08 ft.) radius. This type was not built again.

In the United States a type of small locomotive designed to operate over roads made of logs placed end to end is sometimes used in lumbering operations. This locomotive is set on two trucks and its axles are driven by means of Galle chains from a countershaft operated by the cylinder. The wheel treads are groove-shaped, fitting over the log rails on which they run. It is generally known that Galle chains are used on road locomotives, rollers, gasoline locomotives and certain electric locomotives.

Transmission by Universal Joints. In this category can be placed all transmissions by ball joints. The term ball joint applies here to any device involving wheels mounted on a hallow axle, in the interior of which is a shaft that receives the power from the steam cylinders and transmits it by means of a ball joint, or universal joint, to the hollow axle. On curves the hollow axles take the radial displacement while the interior shafts remain parallel. The interior shafts are coupled by external rods in such a manner as to make the converging movements of the outer axles and the movement of the transverse displacement of the central axle correspond. This ingenious device appears to have been invented by Percival Haywood, who made use of it about 1880 on a small locomotive weighing approximately 2.5 tons and running on a 15-in. gage railroad having curves of 16-ft. radius. (Fig. 4.) The three axles are connected.

E. P. Cowles applied the same principle, but a different arrangement, to a locomotive on a quarry railroad in Kentucky as shown in Fig. 5 (only one-half of the machine is shown, the other half being exactly similar). From the figure it may be seen that only the central carrying axle of each truck is hollow, containing a rigid shaft *a* acted upon by the steam cylinders. The other axles are coupled by external connecting rods, in the middle of each of which is provided a slot in which slides the crank pin of the shaft *a*. The shaft *a* is carried on external supports and is connected with the hollow axle by a central universal joint.

The inventor utilized the peculiar idea of operating both trucks from the same cylinders in order to simplify the general construction of the machine. To accomplish this, each piston rod was arranged to pass through both covers of its cylinder and to engage at each end with a connecting rod. Due to the obliquity of these connecting rods, however, their midpoints of stroke

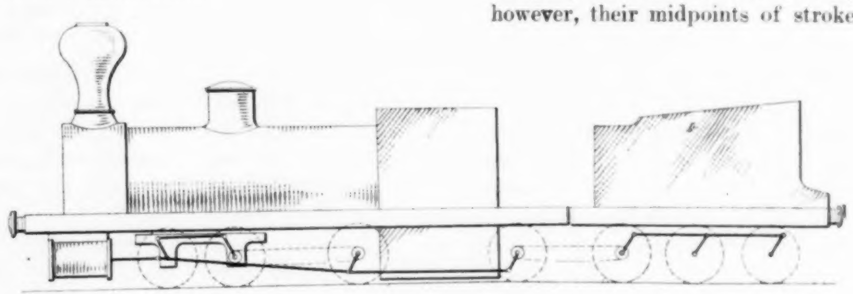

FIG. 3 LOCOMOTIVE "BAVARIA" BY MAFFEI

did not correspond to each other, and a sliding of the wheels on the rails twice in each revolution resulted. This difficulty could have been avoided by the use of two pistons in each cylinder, one for the forward truck and the other for the rear truck, but that would have complicated the machine.

TRANSMISSION BY RECIPROCATING MOTION

This class includes such systems as make use of connecting rods, equalizers, etc., for connection of the convergent axles. The author considers it advisable to call attention in a general manner, however, to the fact that this classification cannot be very rigorous because certain arrangements might belong to two classes at the same time, owing to the multiplicity of parts entering into their construction.

The mechanisms of this class may be divided in the following manner: Coupling of convergent axles by connecting rods located in the longitudinal axis of the engine, these connecting rods being either simple or double, rectilinear or triangular; coupling by oscillating levers or equalizers; use of a free axle

[1] Straight-link roller chain.

coupled by connecting rods to the converging axles, and coupling of axles by means of external connecting rods of which the length varies with the radial displacement of the axles.

Coupling by Connecting Rods Located in the Longitudinal Axis of the Engine. The use of central connecting rods acting on spherical crank pins located in two contiguous axles is a very simple idea, but there is serious difficulty in passing the dead center. This can be remedied in several ways. In designs presented for the Semmering Competition, Maffei proposed to locate, side by side and in the center of the axles, two connecting rods acting at right angles on cranked portions of the axles. It is easy to see that this solution of the problem was not a rigorous one, since the connecting rods are not on the axis of the engine, although they are very close to it. A certain amount of play had to be allowed between the pins of the cranks and the brasses of the connecting rods, which would finally result in causing a breakdown of the transmission.

Thouvenot took up this idea of locating rods on the axis of the engine about 1860. He deflected the connecting rods so as to bring them back into the axis of the engine, as shown in Fig. 6. This arrangement does not appear to possess sufficient strength.

C. Aliges, former engineer of the Cail factory in Paris, developed a design for a four-axle locomotive (Fig. 7), in which one of the two axles forming the truck was connected with the driving shaft by a central connecting rod and the other with the third axle by a like arrangement.

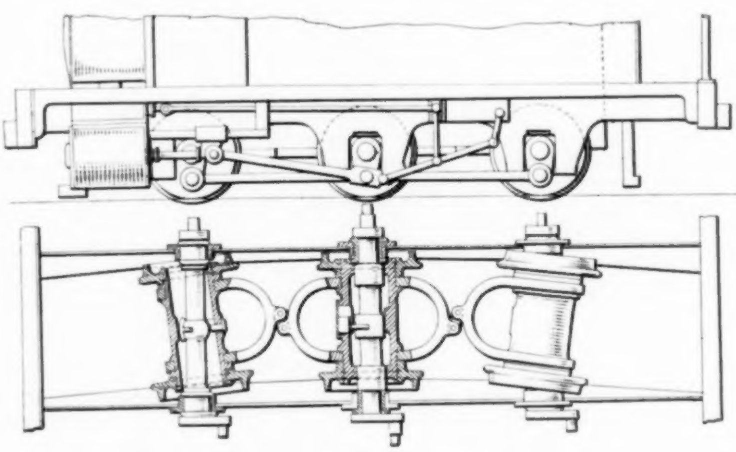

FIG. 4 HAYWOOD'S HOLLOW-AXLE LOCOMOTIVE

De Bergues, of Manchester, proposed an arrangement for inter-connecting the axles of a locomotive and its tender by means of central coupling rods acting on cranks in these axles, the coupling rods being driven by vertical oscillating levers. This arrangement embodied two similar systems located very close to the longitudinal axis, with cranks at right angles to the axles.

Coupling by Oscillating Levers or Equalizers. The idea of using oscillating levers for coupling convergent axles was first disclosed about 1855 in an invention by Lucien Rarchaert, who tried very persistently to realize it. This system has been very favorably reported on, but has never been actually used. A German engineer, Christian Hagans, of Erfurt, invented an arrangement which he applied at first to small locomotives and after, with some modifications, to large five-axle locomotives with three fixed axles and two axles forming a truck, as shown in Fig. 8. The axles of the truck were acted upon by a vertical lever, *a*, oscillated through the intermediary of a longitudinal rod by lever *a'*, oscillated by the piston rod. The upper end of the lever *a* is connected to the top of an equalizer, *b*, articulated in the middle and having its lower extremity attached by a distance rod to the rear axle, *c*, of the truck. The result of this arrangement is that if, on curves, the axles of the truck are displaced, the lower part of the lever ı has a displacement in the same direction and to the same amount, so taking care of the convergence of the axles.

The Hagans system was at first considered quite a success on the Prussian State Railroads on five-axle coupled locomotives weighing 72 tons in service, but it has since been entirely abandoned. As a reason for this was given the fact that the introduction of locomotives with five axles, parallel and coupled by ordinary side rods, has made the complication and expensive maintenance of the Hagans machine unnecessary. However this may be, we may say that this system has probably been supplanted by the Engerth system, no doubt one of the most widely applied arrangements for operating converging axles.

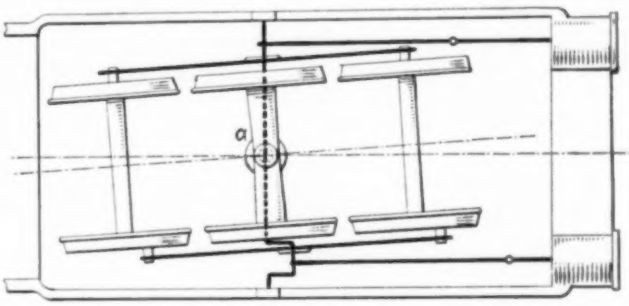

FIG. 5 COWLES' HOLLOW-AXLE LOCOMOTIVE

The Johnstone system, which has been applied on several large duplex locomotives built in the United States for the Central Mexican Railroads, has also some resemblance to the preceding type. Fig. 9 shows one-half of this locomotive, and the other half is entirely similar. The piston rod (or rather rods, since there are three of them, there being two cylinders placed side by side) acts on the middle of a lever *a*, which is vertical when in its normal position. The main connecting rod is attached to the lower extremity of this lever, while from the upper extremity a short coupling rod connects to the top of equalizer *b*. This equalizer oscillates about its middle and operates from its lower end a connecting rod to a crank pin set at 180 deg. from the working pin of the counter-crank. From the figure it is seen that the lever *a*, to which the piston rods are attached, moves always parallel to itself, vertically on straight track and at a slight incline on curves.

Use of Free Axles. The use of a free axle coupled by connecting rods with radial axles appears to date back to the Semmering Competition. Maffei there presented several designs in which the axles of locomotives and their tenders were coupled by inclined or triangular connecting rods. A similar design (Fig. 10), submitted at the same Competition by a Hannoverian engineer, Kirchweger, shows a locomotive carried on two trucks having two axles each, the coupling of the trucks being effected by an arrangement of this kind. It may be seen that there is a connection between the journal boxes of the wheel axles and of the free axle.

The Austrian engineer, Pius Fink, tried to retain in the Engerth machine its original property of total adhesive weight by substituting for the gear train an articulated device. He

built three locomotives, which were in service for several years, but they are not built now. The locomotive had three axles and the tender two, as in the Engerth machine. Dredge and Stein in England resorted to the use of a free axle and a central triangular connecting rod for coupling the axles of a locomotive with those of the tender.

The inventor, Rarchaert, to whom reference was made above, after having abandoned the system of oscillating levers, designed an arrangement coming under the present category (Fig. 11). This was applied on a locomotive with two trucks having two axles each. The cylinders operated a free axle coupled with the carrying axles by a triangular central connecting rod. The pins of the cranks had spherical heads. The locomotive was in service on the railroad between Fougérès and Vitré and from Orleans to Chalons. It gave good results, but at the death of the inventor experiments with it were discontinued.

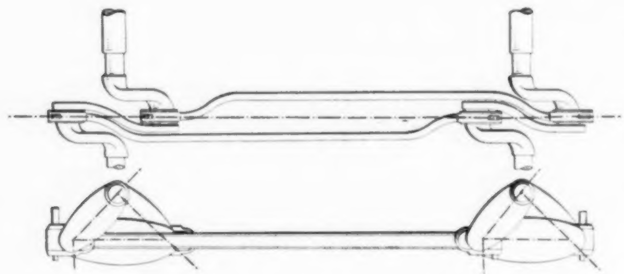

Fig. 6 Thouvenot's Locomotive with Rods on Axis

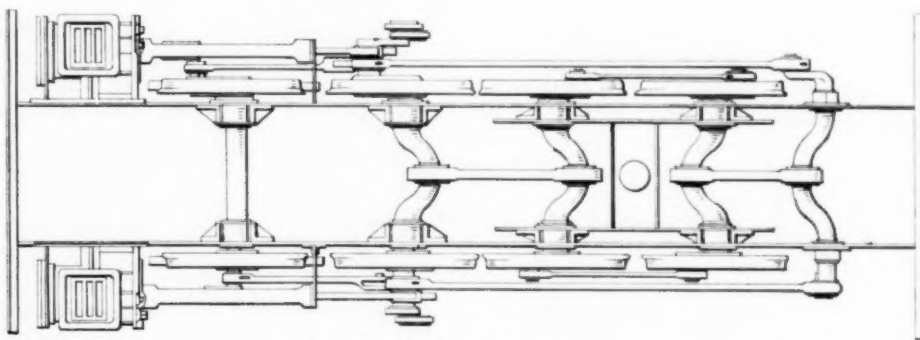

Fig. 7 Aliges' Four-Axle Locomotive

The use of a loose axle may be combined with that of external coupling rods in which are provided slots, and in these slots, again, glide the coupling pins of the radial axles. An arrangement of coupling rods of this type was used in the Cowles system, mentioned above (compare Fig. 5). The Köchy system (Fig. 12) also furnishes an example of this arrangement. A third example is found in the design presented by the engineer Gouin, author of the system employing oscillating levers similar to the first system of Rarchaert. This model represents a combined locomotive and tender with five axles, of which the two rear ones form a pivoted truck. These axles are coupled by connecting rods having an open or slotted link in which slides the pin of a crank forming the terminal of a free axle. This cranked free axle is in turn coupled with the third axle of the machine.

Finally, the well-known designer, Krauss, of Munich, proposed, in 1893, an arrangement permitting of the operation of the axles of a truck by steam cylinders carried on the main frame of the engine, as shown in Fig. 13. To accomplish this, the crank pins on the driving shaft carry pin blocks working in slots in the trussed connecting rods. It may be seen that the use of such connecting rods with slots is subject to serious objections. Stress is exerted on the crank pin in a vertical direction only and, moreover, the pin blocks have on curves a periodic displacement in a direction transverse to the axis of the connecting rod. As a result of this, friction and considerable wear is likely to ensue, rapidly producing play, shocks and dislocation of parts. None of these systems appear to have been utilized practically.

External Connecting Rods, the Lengths of Which Vary with the Convergence of the Axle. In this connection reference will be made first to the Klose system, which has been fairly widely applied. Fig. 14 gives an idea of this system. It may be seen from this figure that the crank pin of the working axle carries a kind of rocker lever to two points of which are connected the coupling rods of the other axles. The other two points are connected to the extreme axles by a system of connecting rods and triangles in such a manner that the convergence of the axles corresponds to the variation in length of the coupling rods. This system has been employed in locomotives having a gage of 1.76 m. (5.77 ft.) on the Bosnian-Herzegovinian Railroads and on large five-axle locomotives of the Würtemberg State Railroads.

An arrangement proposed by a Brazilian engineer, G. Fretl, might also be cited. In this a double horizontal box engages with the crank pin of the middle axle and, by bearing on the coupling rods of the two other axles, increases or decreases the length of these coupling rods when the middle axle is transversely displaced on a curve.

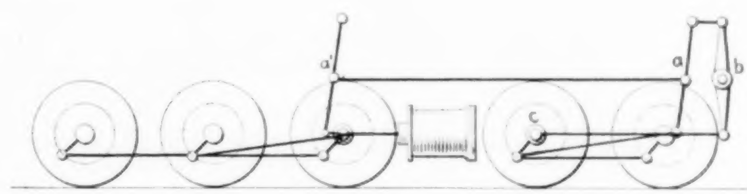

Fig. 8 Hagan's Five-Axle Locomotive

CONCLUSION

In this paper the author has indicated the most interesting arrangements, so far as he knows, which have been proposed for operating the converging and parallel axes on a locomotive by a single pair of steam cylinders. If he has failed to mention any, especially those of American origin, it has been done unintentionally and he apologizes for it in advance.

An examination of these devices gives the impression that all of them involve a serious inconvenience, and that all of them can operate in a satisfactory manner only when they are in vertical play, parallel to the longitudinal axis of the engine, *i.e.*, when the latter runs along straight sections of track. But such is not the condition on curves where the transmission element acquires a certain amount of obliquity, which necessitates the use of pins or spherical parts more difficult to lubricate.

This obliquity introduces differences in length and further play between the parts, and this, in turn, leads to shocks and rapid wear of parts. Hence the maintenance of mechanisms of this kind becomes necessarily more costly than that of the ordinary locomotive transmissions.

Notwithstanding these difficulties, the author believes that in view of the ingenuity which has developed in the study of this question during so many years and by so many inventors,

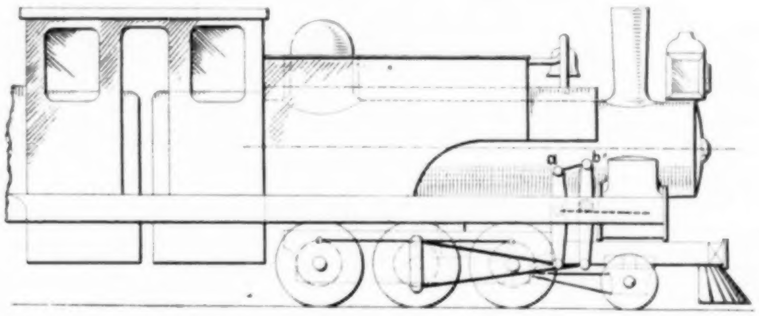

Fig. 9 One-Half of Johnstone System Locomotive

it would be hard to predict that a system may not finally be found combining all the conditions essential to the practical operation of such a device. On the other hand, however, can it not be questioned whether researches in this direction are of any actual utility to-day when there is no hesitation with regard to coupling directly the largest number of parallel axles by external connecting rods and when there are other perfectly satisfactory solutions of the problem based on a different order of ideas?

As a matter of fact, since 1861 and more than fifty years ago, J. J. Meyer, an eminent engineer and author of the first system of articulated locomotives which has given practically satisfactory results, wrote the following:

> In the systems proposed for coupling in a rigid manner in whatsoever way it may be, the several axles belonging to two diverging trains, the addition of coupling mechanism introduces a greater complication than the addition of two extra steam cylinders, and the maintenance of these mechanisms, as well as keeping the drive wheels rigidly to the same diameter, will be of greater cost than that of the two extra cylinders and the two mechanisms, without taking into consideration the loss in efficiency.

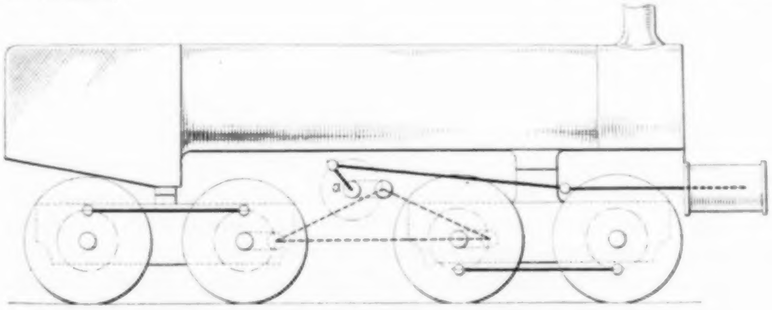

Fig. 11 Rachaert's Free-Axle Design

What has been said above is all the more true to-day, since, in addition to the Meyer machine, we now have the Fairlie system and the author's system, which was the last to come and which has received in recent years such important and remarkable application in the United States, thanks to the energy and skill of American engineers and builders.

DISCUSSION

E. A. Averill. It is impossible in a two-cylinder locomotive to obtain a tractive effort of 100,000 lb., as far as the cylinder is concerned. In view of the limitations of the satisfactory factor of adhesion and safe weight on each driving axle, such tractive effort would necessitate the use of six-coupled drivers. Six-coupled drivers of 60 in. diameter means a driving wheel base of approximately 21.5 feet, which would be impossible for ordinary use, and almost impossible in any case. In this country we have not quite reached 100,000 lb. tractive effort, but we have reached 84,700 lb., and we have also reached the 22 ft. wheel base; and the step to 100,000 lb. tractive effort is one that is desired and probably will be taken. There is an important problem to solve in connection with the very long wheel base required, however, and this paper is particularly timely and should receive very close attention.

The paper itself is mainly historical and contains largely negative information, because the constructions shown are mostly those of failures. They certainly show how the problem cannot be solved, and that is very frequently the most important information that we have.

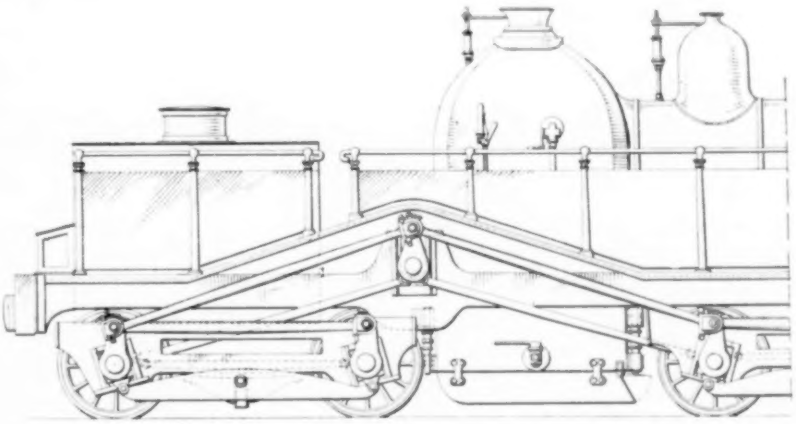

Fig. 10 Free-Axle Locomotive by Kirchweger

Carl J. Mellin (written). The excellent paper by Mr. Mallet is a valuable addition to the history of the development of the locomotive, and one from which references are readily obtained as to what has been done toward the solution of adapting driving axles to curves. This problem has been under constant consideration from the beginning of the locomotive era to the present day and has occupied many minds.

Various forms of gearing were among the first means sought to transmit motion from one set or group of axles to another, each set of axles to be capable of independently adjusting itself to the curvature of the road. This has probably been the most successful principle, through the range of the numerous designs made for this purpose, within the size and weight of the engine where one set of cylinders could supply the power.

The first application of chain transmission was also made at an early date, but probably owing to defective or insufficient strength of the chain this method was abandoned at the outset, although reintroduced at a comparatively recent time. With a more suitable design of chain, a number of log engines have

been built and are reported doing satisfactory service. In a rougher roadbed they permit greater freedom of the axles than do coupling rods.

Theoretically the most correct method for self-adaptation of individual axles to curves, is probably the Haywood idea. It does not appear, however, that this can be applied to any but light engines, due to the unfavorable manner of carrying the weight on the crank axle on the ball connection between the frames. It is also a question whether the wheels will run steady on a straight track, not being confined by any more rigid bearings than the single ball in the hollow axle. This remark holds good also for the hollow axle designs of Cowles, and Klinn and Lindner.

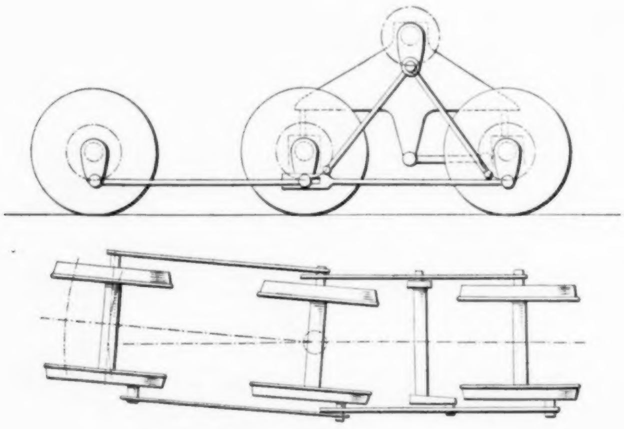

FIG. 12 KÖCHY FREE-AXLE SYSTEM

The various other designs are not applicable to modern sizes of locomotives, but have nevertheless served as stepping stones for further progress to meet modern demands of simple and practical applications; and by the introduction of the four cylinders, followed by the Fairlie designs of double swivelling bogies and further by the application of the compound principle, the Meyer and Mallet systems, were brought into existence.

W. F. KIESEL, JR. (written). Mr. Mallet has given us a most interesting historical presentation of attempts to provide a flexible drive for coupled wheels on driving axles which are permitted to assume a radial position. Apparently few of these designs have reached the experimental stage and none have come into general use. This is sufficient indication that the probability of the schemes are doubtful. The further fact that other solutions to the problem, less expansion and complicated, have been found would lead to the conclusion that such schemes, as illustrated in this paper, will likely never be adopted, as their only advantage would be that all the axles can be driven from a single set of cylinders.

The weight and size of modern locomotives are so great that the cylinder diameters are now as large as road clearances will permit. If larger locomotives are built, and some have been built, the application of two or more sets of cylinders will probably be obligatory. If the number of sets of cylinders is increased, the Mallet type of locomotive is the logical type to use, as with that type no change in customary construction of side rods, pins, etc., is necessary. In the Mallet locomotive, all necessary flexibility that may be required on account of track curvature can readily be obtained, making it unnecessary to consider further the flexible drive. For the reasons given, it is extremely questionable whether further research on the subject of flexible drive would be anything more than an interesting intellectual pastime.

Another reason why such types are not likely to come into practical use is that the loss in efficiency would be greater than the loss engendered by carrying 10 to 15 per cent of the weight of the locomotive on truck axles.

The Mallet type answers the same purpose, is more efficient and less expensive, and has deservedly established itself as a permanent standard on railroads in general.

G. R. HENDERSON (written). To the writer, the most interesting clause of the able paper by Mr. Mallet is that in which he quotes Mr. Meyer as considering that the extra complication of the various methods of connecting different trains of axles is less desirable than additional cylinders, with articulated pipes. It seems that there are other points in favor of the additional cylinders, more important than the cost or efficiency, thermally considered.

When a large number of axles are operated by one pair of cylinders, we have the following objectional features: *a* Large and unwieldly cylinder proportions and parts, *b* great loads on rods, crossheads, guides and main crank pins, *c* heavy rods

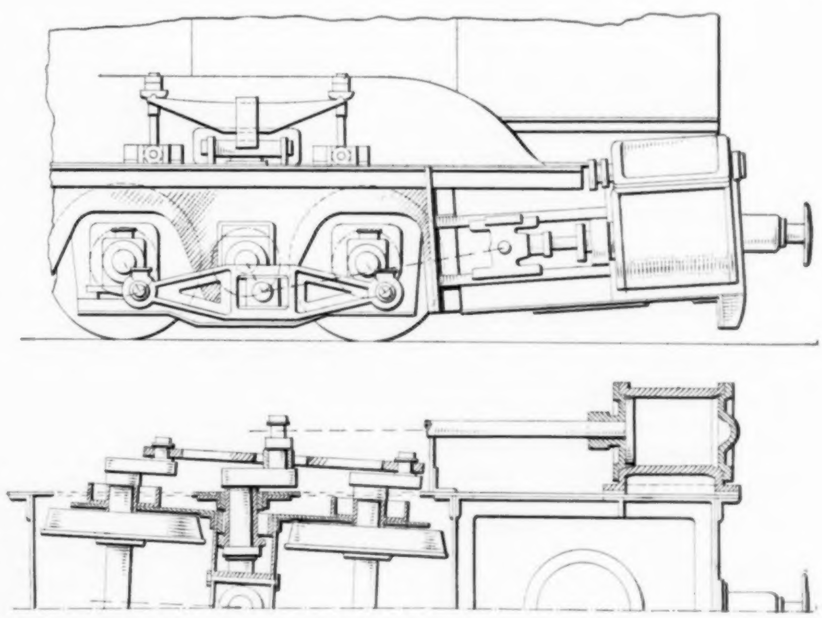

FIG. 13 KRAUSS' SLOTTED ROD ARRANGEMENT

and reciprocating parts, *d* increased difficulty in lubricating the bearings and rubbing surfaces, *e* greater labor in making round house repairs and adjustments.

When operating on the road, the most objectionable feature is found in the loss of headway due to slipping of the drivers practically stalling the train on heavy grades, whereas, in the Mallet type of locomotive, it is a well known fact that the drivers of both high and low pressure cylinders practically never slip at the same time.

Thus, should the high pressure unit slip the wheels, the receiver pressure at once rises, stopping the slippage and causing the low pressure unit to increase its work momentarily,

thereby retaining at least half of the tractive force (as the throttle need not be closed as in single expansion locomotives) and utilizing the steam exhausted from the high pressure cylinders with little if any waste. Should the low pressure unit slip, then the receiver pressure is reduced, throwing more work on the high pressure unit; and the result is the same as before, only reduced pressure steam being wasted, and the tractive effort is still one half or more as the throttle need not be closed.

The writer considers this one of the most valuable features of the Mallet type of locomotive, and believes that this point is not given sufficient consideration in ordinarily selecting locomotives for heavy drags.

W. E. WOODARD[1] (written). It is opportune that the presentation of this paper coincides with the introduction, into this country, of an arrangement which accomplishes in a somewhat different way the purpose of the various schemes described.

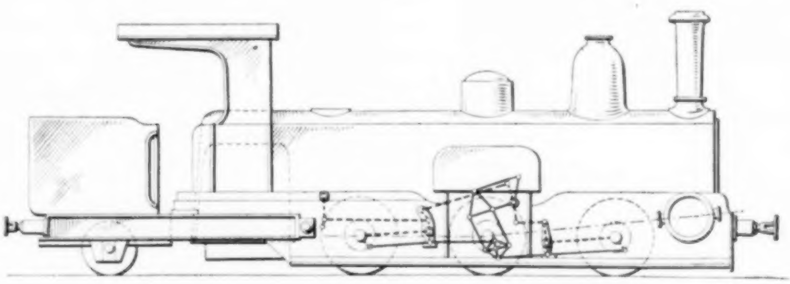

FIG. 14 KLOSE VARIABLE LENGTH ROD SYSTEM

From the standpoint of tracking, the problem of operating a long coupled wheel base with a single pair of cylinders could undoubtedly best be solved by arranging certain of the wheels so that they could deflect radially. However, as clearly shown in the paper, this involves mechanical difficulties which so far have appeared to be hard to solve or complicated in application, at least for heavy locomotives. A practical solution would seem to be a compromise construction which permits of lateral motion of certain of the coupled wheels in a plane parallel with the other coupled axles. A comparatively simple side rod construction can be used which will readily take care of the side motion required. The Zara and other similar truck constructions, which have been used abroad, are based on this general principle.

Floating coupled axles, in which an abnormal amount of lateral play is allowed to accommodate the curving of the wheel base, have also been used abroad and to a limited extent in this country. Floating axles with lateral play will certainly allow long wheel base engines to pass sharp curves easily, but their use is open to the objection that they do not contribute any guiding effort to lead the mass of the locomotive around curves, or to steady it on tangent track until the full lateral play is taken up. Moreover, on account of such axles being free to move laterally, almost all the flange wear comes on those coupled wheels which have normal lateral play. The ruling of the Interstate Commerce Commission covering allowable lateral play between driving wheel hubs and driving boxes, lately made, is also an objection to this construction.

It is evident that the design of lateral motion coupled axles which will best meet the conditions of the case should be capable of application to any or several pairs of the coupled wheels. Thus it may be desirable to equip the first and last coupled axle with a lateral motion device, or possibly even the first, last and middle pairs of wheels.

There has recently been placed in service an arrangement of lateral motion coupled axle which meets these requirements. It provides sufficient flexibility to admit of a locomotive having a long driving wheel base curving easily and at the same time affords a definite resistance against lateral motion. This design is in successful operation on a number of heavy ten-coupled locomotives on the New York, Ontario & Western R. R. and has also been used on a similar class of locomotives of unusual weight and power just going into service on the Erie Railroad.

Briefly, the design consists of an arrangement which permits of about two inches total side play of the leading coupled wheels and boxes. This lateral motion is resisted and controlled by a constant side resistance which is obtained through the action of the load carried on the boxes. In this way, a positive gravity control is obtained against an initial side motion of the wheels and throughout the entire range of this motion up to its limit. The side rods connecting this pair of driving wheels with the second pair of wheels are arranged with ball knuckle joint pins and a special design of spherical crank pin.

The principle of applying a yielding resistance to control the motion of the driving axle having lateral play appears to be fully justified by the results of operation so far obtained. Observations of the engines in service show that there is no lateral motion of these wheels on tangent track and on ordinary line curves even when the engine is working very hard at moderate speeds. The tire wear also appears to be about evenly divided between the first and the second driving wheels.

The construction is also applicable to Mallet locomotives, thus increasing the number of pairs of coupled wheels in each unit with a corresponding increase in tractive power.

GEORGE L. FOWLER said that all the designs illustrated in this paper are intended for easement of wheel pressures on curves, and he had made a few investigations of this subject, with apparently astonishing results.

A seeming fact was that the truck leading a locomotive has a very material effect upon distributing the lateral thrust. For example, in the case of a Consolidation locomotive, it was found that on curves the leading truck exerts the greatest amount of pressure on the rail, then the second driver, followed by the first driver, and third driver and fourth driver, in the order named. Running the engine backwards, the rear wheel strikes a tremendous blow and the remainder travel around the curve without much pressure on the track at all.

The same thing was manifest in connection with the Pennsylvania R. R. electric locomotive, that is, that the leading driver on the rear unit was the one that put most of the pressure on the rail.

The distribution of the lateral thrust depends, of course, entirely upon the type of engine. The easiest riding engine he knew of was the old-fashioned American 8-wheel engine, followed possibly by the Pacific, if weight was eliminated, although in a Pacific engine with trailing wheel, the pressure put on the track by the trailing wheel was invariably much higher than that by the rear driver. In this connection, too, the pressure of the tender on the track was found to be very

[1] Schenectady, N. Y.

light, but strange enough in the case of the sleeping cars it was two or three times that of the locomotive.

On a Pacific engine maximum single wheel pressures of from 13,000 to 14,000 lb. were obtained, while a sleeping car would give a pressure of 32,000 to 36,000 lb. He had obtained as high as 32,000 lb. on a freight car, but this was running on an 8-deg. curve at fifty miles an hour.

He thought the speed of Consolidation engines running backward and switch engines should be limited to certainly not more than 20 or 25 miles an hour. Switch engines hauled over his apparatus, running dead in the train, had a marked effect on the track.

He said it was of no use attempting to make a mathematical

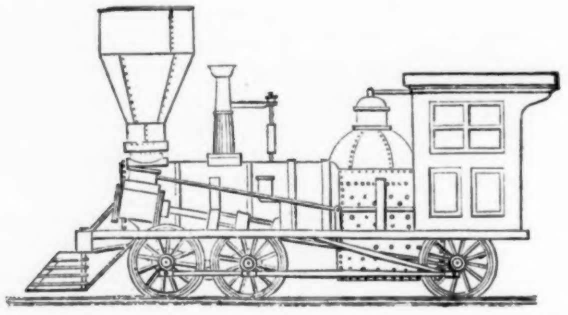

FIG. 15 BALDWIN SIX-WHEEL CONNECTED LOCOMOTIVE

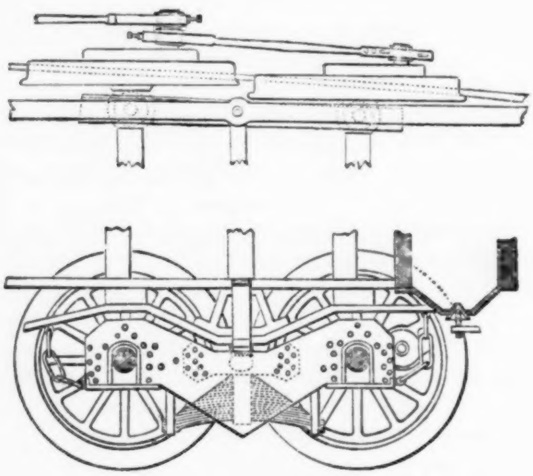

FIG. 16 TRUCK FOR LOCOMOTIVE (FIG. 15)

analysis of what happens on curves. The distribution of the wheel loads on the lateral thrust is quite different from anything in connection with the center of gravity. For example, in the case of the Pacific Locomotive the greatest thrust is by the front truck wheel or main driving wheel, sometimes one, and sometimes the other, but the rear driving wheel thrust is low, while that of the trailing wheel is very high.

In regard to the limitation of side motion in the driving axle, mentioned by Mr. Woodard, he did not feel that there was any difference in a large number of engines, in lateral motion on curves, where the engine is apparently laying over against the outer rail and all the thrust is put there. Side motion on tangent track was apparently a very important element, and an old locomotive with from 1½ to 1¾ in. side motion in the journals slides over a tangent track with an ease that is perfectly surprising.

He thought most of the blow caused by a tuned-up engine was due more to the track. His own experience coincided with that of the Pennsylvania Railroad on the New Jersey & Sea Shore Line, to the effect that if you got a heavy blow at a certain point on the track, at any speed, or in any one particular type of engine, you were apt to get it every time an engine passed over that point. Distortion of the track, too, is a serious matter.

If there is any limitation in regard to the side play in an engine, it should be very liberal. A worn engine does not put any greater stress on the track on a curve than one freshly out of the shop, and it puts remarkably less stress on the tangent track.

E. B. KATTE. Some experience derived from the development of the earlier high speed electric locomotives does not conform with Mr. Fowler's in regard to lateral motion. It was found that in the early electric locomotives equipped with two wheel guiding trucks considerable lateral motion produced a hard knock against the track rails when running into

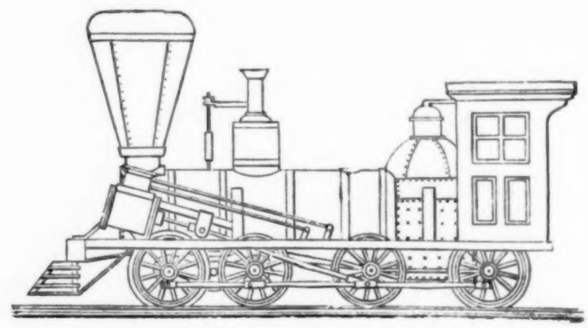

FIG. 17 BALDWIN EIGHT-WHEEL CONNECTED LOCOMOTIVE

or leaving a curve. The low center of gravity accentuated the blow and at 70 or 75 miles an hour the cumulative shock was considerable, while the same locomotive with the lateral motion reduced by hub shims was run up to 85 miles per hour without producing a blow against the rails. Unfortunately, the locomotive had to be shimmed up so tightly that it would not take the short radius yard curves, and other means to prevent the lateral rail thrust had to be found.

ROY V. WRIGHT asked whether it were possible to provide a large enough cylinder on a locomotive to take care of six-coupled axles, and C. D. Young asked what were the limitations to one design. What was the maximum play that could be given the front and rear axles?

W. E. WOODARD replied that he thought this was possible. Such a locomotive would probably take a 32 or 33 in. cylinder, well under the size of those used on the Mallet engines. He did not see any obstacle in the way of our proceeding up to a 100,000 lb. tractive effort simple locomotive. With a larger cylinder the centers would have to be thrown out further, and to prevent side vibration the wheel base would have to be made considerably longer.

In reply to Mr. Young, at present we have only one 1⅛ in. play on each side, but we could probably arrange for one 1½ in., or possibly more.

C. D. YOUNG said that he could see no particular difficulty in reaching 100,000 lb. tractive effort in a locomotive other than of the Mallet type, but did not believe that the use of two cylinders was the only way to do it. It should be done with two pairs of simple cylinders, or with three simple cylinders, or if two cylinders are designed to keep within the clearance

diagram of the right of way, by increasing the boiler pressure and limiting the cut-off. In that way the long overhang of the main pin which results from the wide spread of cylinders would be overcome, as well as cylinder clearance.

If the cylinders were made large enough to limit the full gear position to a reasonable cut-off, he thought that a boiler could be made which would develop the possibilities of 100,000 lb. tractive effort with two or three cylinders. He saw no use, however, for such a locomotive if the boiler could not supply enough steam.

There should be three or four cylinders large enough to permit the valve gear to be so arranged that the maximum cut-off would not be over 65 or 70 per cent, thus making it possible to develop full tractive effort at a reasonable water rate.

The water rate of the two-cylinder engine, working in full gear at seven or eight miles per hour, is about 31 lb. per i.h.p. hour with 125 deg. of superheat. If the cut-off is reduced to 50 per cent the water rate drops to 18.5 lb. The difference in boiler requirements between

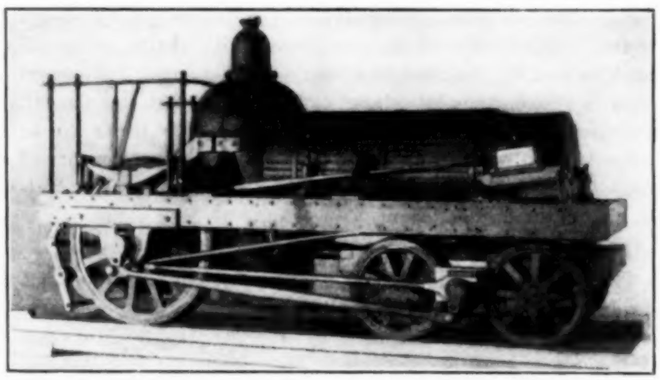

Fig. 18 Gear-Driven Truck Locomotive

these two valve gear positions is evident. Likewise, if two cylinders are used and the boiler pressure is increased a sufficient amount to limit the cut-off to 50 per cent, corresponding results would be obtained, so far as the water rate is concerned, but with such an arrangement, some special provision should be made in the valve, or by a special starting valve with the two-cylinder locomotive.

S. M. Vauclain (written). I have read with great interest the author's historical account of the development of the different systems of radial axles on locomotives operated by a single set of cylinders.

Mr. Mallet's paper covers only the use of transmission adapted to curving when such a transmission is driven by steam cylinders. Electric drive lends itself to the use of radial trucks without serious complications, and the various systems employed both in this country and abroad have been described so frequently that a further description will be of no special interest.

In 1842, Mr. Baldwin took out a patent on his 6-wheel connected locomotive in which the four front drivers were combined in a flexible truck. This locomotive was especially adapted to use on American roads then existing, which had extremely sharp curves, and a large number of locomotives of this type were built and were very successful. The original engine of this type, as shown in Fig. 15, had six wheels, all connected as drivers. The rear wheels were placed rigidly in the frame and had inside bearings. The four remaining wheels had inside journals running in boxes held by two wide and wrought iron beams. These beams were entirely inde-

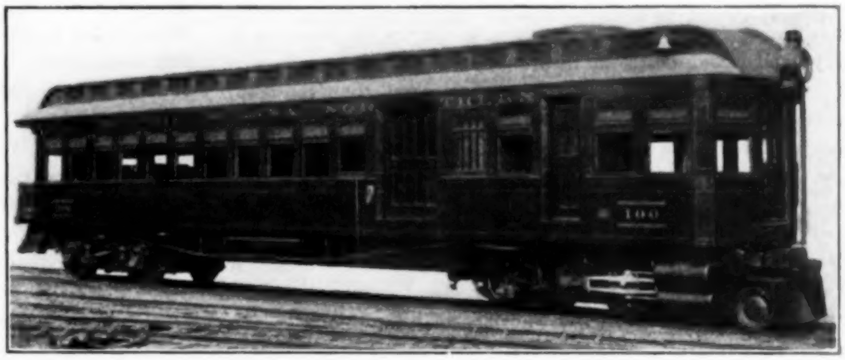

Fig. 19 Motor Car with Pivoted Trucks

pendent of each other and the pedestals formed in them were bored out cylindrically for the reception of cylindrical boxes. The engine frame on each side was directly over the beam, and a spherical pin from the frame bore in the socket between the beam, midway between the two axles, so that the operation of the beam was similar to the parallel ruler. A half plan of this truck is shown in Fig. 16. The coupling rods were also made with cylindrical brasses.

This design was subsequently modified into an 8-wheel connected locomotive, shown in Fig. 17. In this arrangement both pairs of drivers are rigid and connected to the boiler and steam machinery. The wheels of the front truck are connected by side rods to the drivers and the truck frames are pivoted under the engine frame to obtain a parallel movement to the axle when on curves. This lateral movement is possible since the axle journals and the rod brasses are cylindrical in their boxes.

Fig. 18 shows a design in which one driving wheel is coupled to a shaft driving a gear, which in turn drives truck wheels of smaller diameter. The truck is adapted to curves in the same manner as that previously described.

Fig. 19 shows a motor car with a compound engine in which the driving trucks are pivoted and steam is admitted to the cylinders through the carrying bearings. The boiler rotates in the body of the motor car as the driving truck accommodates itself to the curve. The rear truck in this arrangement is simply a carrying truck and is not driven. This locomotive was built in 1897.

The foregoing are by no means all of the American designs of locomotives with radial axles, but they serve to show different solutions of the problem, all of which have been in successful operation.

F. J. Cole (written). This paper makes readily available the information contained in technical literature extending over many years regarding the most interesting arrangements which have been used or proposed for parallel driving mechanism arranged for operation by two cylinders, having all the weight available for adhesion, with the advantages of radial axles for traversing sharp curvature.

It is probable that such designs, with the exception of geared locomotives, similar to Shay, Climax, etc., attract much more serious consideration abroad than in this country. It is significant, however, that few, if any, of these locomotives are now in operation, the inherent difficulties and complications probably being so great that they more than offset the advantages gained. They have also been superseded by designs having more than two cylinders and in which the necessary radial action is obtained by swiveling trucks, such as the Fairlie and Pechot. Usually such engines are built for slow service on roads with heavy grades and sharp curvature. The use of four cylinders is often more economical, all things considered, than the complication incident to special forms of radial axles.

The author, in the invention of the locomotive which bears his name, has done more to render unnecessary such designs (except geared) than probably any other man. These Mallet or articulated locomotives, as is well known, are adapted to the widest possible range of service. Originally they were intended for military use for very narrow gauges and extremely sharp curvature, the track following the natural undulations of the ground with but little grading. At the present time in this country, we see their very highest form of development in hauling the heaviest tonnage trains in the world, such for instance, as the 2-8-8-2 type for the Virginian Railway, having a tractive power of 115,000 lb. when working compound and 135,000 lb. when working simple for short distances; it has a weight of 481,500 lb. on drivers and 542,500 lb. total in working order. It is probable that even these figures will be exceeded in the near future.

We see again modifications of this design in the Triplex, which is a triple articulated compound, with the weight of the tender utilized for adhesion. Such locomotives are suitable only for very slow service because of their boiler or steaming limitations.

Engines of this kind operate with the axles of the front engine substantially radial to the track. They can be built in all designs from 0-4-4-0 to 0-10-0 or 2-10-10-0 and many other intermediate modifications of arrangement of trucks and driving wheels carrying either all the weight on the drivers or provided with leading and radial trailing trucks suitable for the road conditions under which they operate. I agree, therefore, with the author that it seems unnecessary to consider seriously many of the designs shown in the paper.

Five-coupled engines, having leading and sometimes trailing radial trucks with lateral play in the front and occasionally in the rear driving axles, can be operated successfully on sharp curves. It is better practice to use some form of gravity or spring resistance in axles having much lateral play in order to distribute the flange wear. Whether for safety these axles actually require centering devices or control, depends upon the speed and other conditions under which the engines are operated. Such devices are now available in simple form, which operate successfully. It is only in heavy grade service that locomotives having all the weight on the drivers can be operated satisfactorily. The horsepower in such service is relatively small, therefore the steam requirements are not so exacting. For fast service, in order to get sufficient boiler capacity for conventional types of locomotives it has been found necessary to carry a certain portion of the engine on leading and sometimes on trailing axles, not only to provide for the guiding of the locomotive on curves, and therefore to make the operation safe, but to permit the construction of a boiler of sufficient size to provide the steam required.

W. F. M. Goss said that from our study, experience and understanding of the general problem, it would appear that the developments described in the paper are not of great practical value. Our experience seems to have passed the stage of development with which Mr. Mallet deals. The fact is, however, that we can never tell what the next step will be, because we can not predict the conditions that are to govern it. It is perfectly clear, for example, that the chain transmissions shown in these designs were destined to failure at the time they were employed, for in that day chain drives were crude things; but it is equally clear that if for any reason we should desire to-day to couple up locomotives with chains, we could do it successfully because practice in chain gearing has passed from an experimental stage to one of great refinement. Changing conditions, therefore, emphasize the profit to be derived from study involving the historic development of mechanisms. I regard the masterful presentation of Mr. Mallet as a contribution to our Proceedings of high value.

The Author was unable to present his paper in person, but it was presented by E. A. Averill, Mem.Am.Soc.M.E., who also contributed to the discussion. A letter written by Monsieur Mallet and received subsequent to his manuscript included the following paragraph which, he said, established a very clear case of priority in favor of an American designer:

The author wishes to recall here that probably the first case of transmission by convergent axles on a locomotive from a fixed steam cylinder by means of a connecting rod located in the longitudinal axis of the engine, is to be found in the locomotives built in 1832 by Horatio Allen for the South Carolina R. R. In this engine the main rod had a vertical jointing with a small stub end and large head spherical journal, so that, on curves, it lent itself to an oblique action on the central arm of the axle.

FOUNDATIONS

BY CHAS. T. MAIN, BOSTON, MASS.

Member of the Society

After the location of a plant has been decided upon, and the site selected, a sufficient number of borings should be made or test pits sunk to determine the character of the soil and its bearing capacity. Such exploration will reveal whether the site is suitable or whether the cost of foundations would be excessive. If the site is found suitable, the knowledge of the underlying soil or rock is necessary for the proper and economical design of the foundations.

The borings are made for the purpose of determining at what level firm soil is to be reached, if at all; the thickness of any stratum of firm soil; the character of the underlying material; the level of the ground water; whether piles will be required and the probable length of the same.

It is of great importance to support all structures on a stratum of soil below silt or peat. If the structure is to be a heavy or an important one and it is found necessary to use piles, some of the borings should be carried to bed rock, if possible, and dry samples of the soil should be taken every few feet in depth. The samples should be examined as soon as taken, as the moisture in them evaporates and their character changes rapidly. If uniform conditions are found a few widely scattered borings will be sufficient, but where the conditions vary a greater number should be made. A description of the processes and values of borings is given later.

If it is found necessary to drive piles, test piles should be driven and careful records kept. Piles should be tested by loading until marked settlement takes place and careful readings should be made before and after each increment of load. If possible loads should be allowed to rest at least 24 hr. after each increment, except the final load which should remain on at least 48 hr. unless a failure of pile or testing platform prevents. All test piles should be pulled, whether load-tested or not, to determine their condition and suitability for the work.

From the accumulated data obtained from borings, test pits, test piles and from pile loading tests, it will be possible to select working loads for the piles suited to the building to be supported. In general the working pile values should have a factor of safety of not less than $2\frac{1}{2}$ based on a load producing $\frac{3}{8}$ in. total settlement by test. However, it may be desirable to select a working load based on allowable settlements such as $\frac{1}{16}$ in. to $\frac{1}{8}$ in. The values of the factor of safety and working or ultimate settlement are all to be fixed to suit the class of structure to be supported.

Buildings which are to contain moving machinery or delicate instruments would naturally require piles with fairly large factors of safety, while in cheap one-story structures for storage purposes the safety factors could be much lower. Where piles are not load-tested, the values given by the Engineering News formulæ can safely be used. These formulæ are:

For a pile driven with a drop hammer

$$P = \frac{2\ W\ H}{S + 1}$$

For a pile driven with a steam hammer

$$P = \frac{2\ W\ H}{S + 0.1}$$

in which

P = safe load in lb.

W = weight of hammer in lb.

H = fall of hammer in ft.

S = penetration or sinking in in. under the last blow

Test pits should be sunk for determining the level of the ground water and for making a study of the soil for a reasonable depth more accurately than can be done with borings. Both the maximum and minimum levels of the ground water should be determined, the maximum for obtaining the hydrostatic head on waterproof basements and the minimum for finding the safe level for cutting off wood piles or to determine if it will be better or cheaper to use concrete piles.

When the structures are of any considerable magnitude and piling is unnecessary, tests should be made to determine the bearing capacity of the soil to insure the maximum economy in design. Having ascertained the condition of the soil and decided that piles are not necessary, and having also decided upon the maximum pressure to which the soil is to be subjected, the widths of foundations can be determined from the estimated loads.

Solid ledge forms the securest support for foundations, providing it goes all round the building. Part earth and part ledge are apt to cause unequal settlements. The ledge, if uneven, should be leveled off and, if on a slope, cut to form steps to give an approximately horizontal surface. In going from rock to earth, the footing courses of the foundation should be spread out to a greater width on the soil next to the ledge, gradually narrowing into the regular width for earth foundations. If there should be any unequal settlement, it will be spread over a greater length of the superstructure and probably save cracks in the walls which might otherwise occur at the junction of earth and rock.

Hard gravel or hard pan is quite as desirable as ledge. Gravel and sand are also good when kept dry. A stratum of 6 to 8 ft. of hard-compacted and well-cemented material, even if underlaid by softer material, is usually safe. With dry sand, this stratum should be double the thickness.

Clayey soils are somewhat treacherous. Upon exposure to the air they dry and crack, and exposed to rain they become semifluid or expand. With this soil it is best to open only a small portion of the trench at a time and quickly fill in behind.

With buildings used for industrial purposes, there is usually more or less vibration caused by machinery in motion, and the loads carried by the foundations should be less per square foot of bearing material, or less per pile, than in buildings which are not subject to such vibration. On soft clay or running sand confined, the pressure should not exceed $\frac{1}{2}$ to 1 ton per sq. ft.; medium blue clay, whether or not mixed with fine sand, 1 to 2 tons; hard clay, 2 tons; compact sand and gravel, 2 to 3 tons; hard pan, 5 to 6 tons per sq. ft. Under favorable conditions of soil and use of building, these loads may be exceeded.

In any building with a uniform firmness of earth under it, the area of foundations for walls, towers, piers, and other portions of the building should be in proportion to the pressure. The loads on the outside walls may be a little lighter than those on the piers. In case the soil should vary considerably in one portion from another, the areas supporting equal weights should be changed to correspond with the soil. In this way unequal settlements are avoided and the most economical structures of approximate uniform strength obtained.

Where there is unreliable soil, piling must be resorted to. If firm earth cannot be reached by the bottom of the piles, the

Presented at the Annual Meeting of The American Society of Mechanical Engineers, New York, December, 1915. Pamphlet copies without discussion may be obtained; price 10 cents to members; 20 cents to non-members.

supporting force is friction alone. If there should be an underlying firm stratum, even at such a depth that excavation would be too expensive and sometimes impossible, but still within the reach of piles, then piling can be used with good success.

Where wood piles are properly driven, that is, not broomed or broken, the bearing capacity of the piles, when driven into sand, usually shows under the test loads a slight increase over that indicated by the Engineering News formula; but those which have brought up hard and have been crippled will show a much less capacity under the test load than was indicated by the formula.

From tests recently made on wood piles embedded in medium and stiff clay on the site of the new buildings for the Massachusetts Institute of Technology, it was found that for about each 5 ft. of embedment of the pile in clay, 1 ton value could be added to that given by the Engineering News formula for drop hammers.

Spruce or similar soft wood piles without iron points, driven with drop hammer, should be used cautiously where there is a hard crust of gravel or sand overlying clay. Oak piles without iron points will usually penetrate the hard ground and come practically to a standstill without material injury. Any wood pile which is to depend largely upon point bearing for its value should be of oak or southern pine.

When piles are driven through a hard fill and an intervening layer of peat, silt or mud, to the hard sub-soil it will be necessary to reduce the value given by the formula as it contains the values of the hard fill above the intervening peat. This value can be approximately corrected by subtracting the value shown when driving in the fill or a conservative value assumed after comparing with other piles passing through no complication of strata.

Unless Batter piles are used, it is necessary to drive far enough into the solid material to give stiffness to the structure against vibration, especially where the fill above is soft.

Concrete piles should be used where the distance to good bearing material is great, where wood is scarce or the ground water low. Considerable expense may be saved in the foundations under the latter condition.

The three kinds of material commonly used in foundations are dry rubble masonry, rubble masonry laid in mortar and concrete. Dry work is unsuitable for industrial buildings. Stone laid in cement mortar with bedded joints is very satisfactory and should be used where there is an ample supply of stone at a low price. Concrete is most commonly used and is usually the most convenient material to handle, and under ordinary conditions it can be used at the lowest cost.

A foundation for a chimney and other isolated structure having a small base and heavy pressure should be carried to the lowest depth to which it would be necessary to go with any other work reasonably near it, since if it is on sand there is a liability of undermining it.

The preceding is a very general consideration of the subject only, and the second part of the paper is devoted to more extended descriptions and data regarding testing soil, excavations, structures, stability of foundation walls, specifications for concrete, mixing concrete, placing concrete, forms, surface finish and foundations for piers. The following paragraphs are taken from this part.

TESTING SOIL

Wash Borings. These are made with the aid of a tripod, iron or steel casing, drill rod, hose, force pump, bucket, etc. The tripod used to support the casing and drill rod usually stands 12 to 15 ft. high. The casing is usually made of heavy pipe, 2 to $2\frac{1}{2}$ in. internal diameter, and inside it works a heavy hollow drill tube or rod, $1\frac{1}{2}$ in. to $1\frac{3}{4}$ in. outside diameter. This drill rod is fitted at the bottom with a chopping bit having openings in it for the water jet, while the top is connected with a water hose and force pump, the latter usually double-acting. In action, the water is forced down through the drill rod, jetting through the holes at the chopping bit and carrying up the loosened material in the annular space between the rod and case.

Test Pits. Test pits furnish the opportunity of observing the character of soil, its degree of compactness, amount of moisture, etc., but to be of full value they should be carried well below the level of the bottom of the foundations. In cases where the strata change with the depth, a test pit gives no sure indication of the soil below the foundations unless carried deeper than the level of the footings.

Test Rods. Testing soil with a rod is an unsatisfactory method and cannot be relied upon to give accurate information except in a limited number of cases. In a homogeneous material, not too hard, the method is valuable in determining the constancy of varying density and resistance.

EXCAVATION

Work on foundations consists of excavation of earth or rock, including shoring, sheet piling, or coffer dams, and a structure of stone, concrete, brick or timber at the bottom of the excavation, including bearing piles. In nearly all cases the expense of excavation will increase with the hardness of soil and inconvenience for working; but if the excavation is in sand or soft earth, with considerable water to contend with, the cost is largely increased by the necessary structures for inclosing the excavations and sustaining the banks.

Earth is hard in proportion to the amount of cementing material which it contains and its temporary stability also depends on the amount of this material, while its permanent stability depends upon the friction of the particles on each other. The disadvantage of hardness for excavation is offset in many cases by the advantage of the self-sustaining power of the vertical cut for a time sufficient for the work on the foundation to be completed. If a vertical cut is exposed for a long time to the weather, it may become dangerous. The effect of an excess of moisture, freezing and thawing, or drying out is to crack off the bank and gradually to approach the natural slope of permanent stability. If the time required to lay the foundation be very long, or the weather unfavorable, it may become necessary to shore up even in firm earths, but in a much less expensive manner than in material which has a tendency to flow.

Usually, in working in clean sand or gravel below a depth of 5 to 6 ft., shoring may be done by laying in planks horizontally along the sides of the banks, putting in vertical timbers or planks at short intervals and opposite each other, and bracing between them. Even with this sort of shoring, it is well to make it secure, so that no braces or other pieces may drop out and injure any person or perhaps cause a slide.

When sand containing water, or soft clay with running water, is encountered, the saving of soft excavation is entirely absorbed by the expense incurred in sustaining the banks and preventing damage to any adjacent buildings. Sheet piling must be used here, which consists of planks or timbers driven closely together and of a thickness varying from 2-in. plank to large timbers, according to the depth, pressure, and soil. Four-in. plank is about the thickest used in ordinary work. Three to 6-in. plank should be grooved on edges, the grooves to be filled with splines.

Coffer dams are built for the exclusion of water while work is being done. The kind employed depends upon the nature and extent of the work and the strength should be somewhat in proportion to the amount of damage or delay from failure. As the space and amount of puddling material are usually limited, the best and usual form will be a bank of puddle inclosed and supported by a row of sheet piling on each side. Experience has shown that 4 to 6 ft. is sufficient for the puddle to exclude the water; but unless the dam is supported independently, its width must be in proportion to the depth of water, so that it will not be overturned. Good timber should be used here as in ordinary sheet piling and for the same reasons. Where there is room, a bank of sand against the inside sheeting will assist in supporting the dam.

Bag Dams. Where the depth of water is not great, bag dams can be used to advantage. They can be cheaply and quickly constructed and in some cases are almost indispensable. They can be used for shear dams for turning water away from foundations, especially where sheet piling cannot be driven, for repairing breaks in banks and for many other purposes. They are made from strong empty cement bags or gunny sacks filled with sand or other suitable material and securely tied and deposited in the place where they are to be used.

Piling. Where the depth of good bottom is too great to be reached economically by the foundations, approximately 10 ft. or more, it becomes necessary to use piles. The determination of the type of piles depends upon local conditions. If it is necessary to spread the load over as much area of the underlying land stratum as possible, wood piles should probably be used. If it is not necessary to spread the load, a fewer number of concrete piles with higher bearing value can be used. If the ground water is comparatively low down, it may be much more economical to use concrete piles and carry the foundations down to the ground water level, than it would be to use wood piles.

STRUCTURES

Of the structures at the bottom of the excavation there are many forms and kinds. Those most commonly used are concrete stone laid in cement mortar or bedded rock, stone laid with outside joints pointed and then grouted full, and stones laid dry.

Dry rubble work is unfit for industrial buildings. As there is a constant vibration, the few bearing points of the stone, when laid dry, will get worn off and thus cause slight settlements, which, though perhaps not unsafe, might lead to annoying cracks.

The cheapness of suitable building stone in some localities will sometimes made it desirable to use stone for the foundations. Stone laid in cement mortar, with bedded joints, is the surest kind of stonework. With grouted work there is not that surety of filling all the joints. Grout, when made thin enough to run freely, takes a very long time to set and strengthen, and never attains the strength of cement mortar. The sand is liable to settle away from the cement, thus making the final strength variable. Old foundations laid dry may be greatly strengthened by pouring in grout, and pinning them up. The more recent method of forcing grout into old work is used with great satisfaction in many cases.

Concrete, plain and reinforced, is now used almost exclusively for all kinds of foundations owing to its economy, availability, suitability, ease of handling and rapidity of construction and strength. It should be made according to proper specifications, and be properly mixed and laid.

FOUNDATIONS FOR PIERS

Foundations for piers which support columns are subject to more shock than foundations for the side walls, and the footings in buildings which contain machinery which causes much vibration should be ample, so that there will be no settlement. In some cases the footing course is made continuous for the full length of the building. If built of concrete the location of the joints should be predetermined; they should be about half way between column centers and not over 20 ft. apart. Where the bays are large, reinforced footings can be used. It is probably safer and more convenient for construction to design independent piers of liberal area and low soil pressure suited to the load and soil.

The piers above the footings may be of concrete or brick, usually now of concrete. If of brick they should be good hard burned brick laid in cement mortar and capped with stone or cast iron. The pressure should not exceed 15 tons per sq. ft., and as the height increases the area should be increased for stiffness.

With piers or other footings of concrete, if built in steps, the horizontal lap should not exceed ½ the thickness of the step.

DISCUSSION

M. M. Upson presented a written discussion in which he stated that, in his experience, on most sites where the problem of foundation is serious, it is difficult to use the information from either wash or dry borings unless they disclose a substantial bearing stratum. The reasons for this are many, but in general are due to the inability of the average engineer to determine from a physical examination of a small sample of the soil what safe bearing strength it has, or what friction per square foot of pile surface may safely be imposed upon it. Many engineers of wide experience are reluctant to place heavy structures on a site where rock, hardpan, or stiff clay cannot be reached, and frequently valuable real estate remains undeveloped because engineers have not been able to find a good bearing soil within economical reach of the surface.

The idea of carrying heavy monumental buildings or costly steel structures on the friction of piling has not until recently been accepted as good engineering practice, and there is at the present time a large school as yet unwilling to subscribe to the assumptions on which the principle is based. Piling is usually conceived of as a means of carrying the loads from the surface of the excavation through a soft material to a substantial underlying base. It is therefore frequently a shock to be told that the piles supporting certain structures have their points in a material of no greater density and frequently of less density than the material which surrounds their butts.

The engineering prejudice against all friction pile foundations is more or less justifiable, since little information is available in engineering literature on the allowable friction per square foot of pile, and unless the individual has had a wide experience in driving various kinds of piles in all characters of soil, it is quite impossible to safely predetermine the length or the proper pile for the work.

A large percentage of piling work is done in ground which does not have any substantial lower stratum to which the point of the pile can reach. This means that the pile must support its load by friction. The amount of friction per square foot of the surface of the pile is dependent upon two variables, namely, the taper of the pile and the character of the soil surrounding it. Given the same soil, the surface friction increases as the taper increases. This is due to two causes:

a The greater the taper, the greater the tendency to compress and increase the density of the surrounding earth, since a tapered pile subjects the surface of the ground to the maximum initial pressure and thereby overcomes the tendency of the earth to heave around the pile. The density of the underlying material is thus greatly increased. It is obvious that a heaving of the soil releases the interior compression, which in turn reduces the surface friction.

b A unit area on the surface of a tapered pile naturally has a greater vertical component than the same unit on the surface of a straight pile. In the latter instance the vertical strength can be no more than the shear of the earth, while in the former the compression strength of the earth becomes a material factor.

The above statements are based on the assumption that the type of pile used conforms to the essentials of a frictional piling member, and may be tersely expressed as follows:

(1) The form which acts as a penetrating element or the pile itself must not be so cushioned that the major part of the energy of the stroke of the driving hammer is absorbed in the cushion, and must be of sufficient strength to withstand severe abuse.

(2) The compression of the earth secured by driving the form must be maintained while the latter is being removed and concrete put in place. In other words, the substitution of soft plastic and unset cement in a hole made by the driving form will not hold the compression of the soil which has been obtained in the driving.

From the above it may be observed that a lineal foot of piling may represent a supporting power of ½ ton or 3 tons, all depending upon the resistances to which the pile is driven, and on whether the conditions which obtained while the pile is being driven are continued throughout the entire process of placing the pile.

Much thought and money has been expended in experimenting on a simple and inexpensive method to quickly predetermine the probable length and carrying capacity of piles in a given soil. The most feasible method thus far developed is the driving of a series of ¾-in. rods joined together by large cast iron screw couplings. This driving is accomplished by the use of a heavy sledge of given weight and swung through a definitely determined arc. A record is carefully kept of the number of blows required for the penetration of every foot, and the test is considered complete when the resistance of the rods has attained a certain number of blows to the last inch. The extending shoulders of the couplings are analagous to the taper of the pile and test the resistance of the various strata of soil penetrated. By carefully comparing these tests with the actual results of driving piles on the same site, a very interesting analogy is formed, making it possible to predetermine with a fair degree of accuracy the length and the loading.

CHARLES H. BIGELOW said that in a good many cases sufficient attention is not given to foundations, and he had seen quite a number of cases in which there had been practically no foundations put in at all. The reason is probably that foundation work is covered up.

He recalled a case in which a building was put up directly over a 24-in. water pipe, but the owner desired a cheap building and was satisfied.

He thought the matter of foundations required a good deal of attention and care, and that the paper would be of service to anyone requiring to take up the facts of the subject on any occasion.

A. G. MONKS (written). It may be worth while to point to the interesting complication that arises when buildings are constructed on land so valuable that the outside walls or columns must be placed on the lot line and the foundations must be kept entirely within the lot, a condition frequently met with in cities. It becomes necessary then to place a column on the edge of a foundation, the effect of which is similar to that of a heavy-weight swimmer standing on the edge of a raft. Two courses are open to the designer. He may either construct the foundation large enough and strong enough to carry the column, notwithstanding its eccentric position, or he may combine the foundation with one or more others in such a way that the center of the combined column loads coincides with the center of uniformly distributed pressure on the soil under the combined foundations.

Either of these types is, of course, much more expensive than the ordinary concentric foundation, and they are for that reason to be avoided when possible. The first method was more prevalent some years ago when heavy stone masonry was chiefly used for foundations, and still meets some favor when the soil is particularly firm or the loads light. Concrete reinforced with steel bars, which has come so extensively into use in recent years, both for foundations and for the superstructure of buildings, is particularly adapted to the combination type of foundation, and this type has consequently grown in favor along with concrete.

The design of a combination foundation is often intricate, particularly at the corner of a building adjacent to two sides, both of which are on the lot lines. Four columns have then to be carried on one foundation. In some cities the space below the surface of the street is regarded so valuable for present or future subway purposes that by the building law foundations are not allowed to project beyond the street line, and the combination foundation is more frequently required for that reason.

The facility with which reinforced concrete can be handled by the experienced designer, and its adaptability to a wide variation of conditions in the design of foundations, have made possible the easy solution of many problems formerly exceedingly expensive and intricate.

SANFORD E. THOMPSON (written). Almost as important as the bearing power of the soil is the structural part of the foundations. Where the construction rests on columns, a thorough study of the conditions must be made to determine whether single or combined footings are best. In combined footings, that is, footings upon which more than one column rests, the problem of obtaining uniform distribution of the column loads on soil or piles is frequently so complicated, especially where column loads are unequal, as to call for the application of principles which the engineer seldom meets elsewhere. The arrangement of steel and the computation of stresses also present many difficulties.

In general, where piles or unstable soil require a large distribution of area the combined footing is preferable. This also applies in general to a line of columns under the conditions indicated. The footing of course must be designed for the upward reaction between columns. In a floor the distributed loads are resisted by concentrated reactions of the columns. In footings the concentrated loads of the columns are resisted by the disturbed reactions of the soil. It simplifies the problem for the designer who is inexperienced in this type of work to think of the footings as upside down and to consider the supports to be the columns and the loads to be the upward pressure of the soil or the piles. The reinforcement

of the combined footing must be placed in just the reverse position from that in the ordinary beam or slab. It must be in the top of the footing between the columns and at the bottom of the footing below the columns. In simple cases the computations then are similar to those required for floor design. Unequal column loads and especially the arrangement of three unequal columns on the same footing may further complicate the problem.

A retaining wall, as indicated by Mr. Main, is frequently a part of the foundation. A reinforced concrete retaining wall must be designed to resist not simply the stresses due to the pressure of earth, but also the stresses due to shrinkage in concrete and changes in temperature must be taken into account. This is particularly necessary where the foundation wall projects above ground and the building is placed directly upon it. Of course, if a structure permits, definite joints may be placed between different sections. In building construction, however, it is frequently necessary to avoid joints or any noticeable cracks. By placing reinforcement to the amount of 0.3 per cent, or better still 0.4 per cent of the cross section of the wall, it may be built monolithic and noticeable cracking may be avoided even in long walls.

The greatest difficulty is in providing for a bond between sections of the wall laid on different days. Positive adhesion cannot always be assured, but by running full or better still excess reinforcement through the end forms and then spreading a bonding layer of neat cement upon the vertical surface of the old concrete, just before the fresh concrete is placed it is usually possible to prevent separation.

Of special importance in the design is the reinforcement above and below openings in a long retaining wall. As much, or preferably a little more, cross sectional area of longitudinal steel must be used in the sections above and below the opening as in the total section of the blank wall. The forces caused by shrinkage and temperature, which are proportional to the cross-sectional area of the solid wall, are just as powerful at the openings as in the solid wall, so that the section is weaker unless as much steel (which means a larger percentage) is used there as elsewhere. In fact an excess in quantity may be needed because the area, and therefore the strength, of the concrete itself is reduced by the opening in the wall. In addition it is advisable to put diagonal bars across the corners of openings to assist in preventing the starting of any cracks at these points.

F. A. Waldron (written). The use of the Engineering News formula is dangerous unless full knowledge of the character and action of the underlying strata is at hand. Buildings erected on pile foundations in peat or silt have been known to go down two or three feet; in fact, piles have sunk away from the building from their own weight and weight of soil, when driven to the requirements of this formula.

Special care should be taken to avoid driving taper concrete piles in peat formation, as it is like driving a taper nail into a rubber heel and demands too much punishment of the driving mandrel; and these piles will settle if given double the amount required by the Engineering News formula, unless driven to hard pan, which is next to impossible in thick strata of peat.

Piles driven in peat or silt or other formation of varying thickness, where the mass is liable to change by fill and slide or exert a force sidewise, should be tied together, where driven singly on each side of the building, or the groups so arranged or designed to resist the unbalanced lateral pressure.

Particular care should be taken, where soil is filled, in analyzing and counteracting forces tending to spread or force out of position by lateral pressures on the piles, due to weight of fill on strata above hard pan.

ANNUAL MEETING DISCUSSION

IN the January issue of The Journal were published the papers by F. W. Dean on fire tube boilers; L. B. McMillan on steam pipe coverings; Paul A. Bancel on circulation in water tube boilers; Geo. H. Gibson and Paul A. Bancel on surface condenser performance and design; Robert Cramer on higher steam pressures, A. L. Menzin on proportioning chimneys; Mark A. Replogle on the turbine discharge accelerator and Louis Illmer on oil engine vaporizers, all presented at the Annual Meeting, December, 1915. The discussion of these papers, both written and oral, indicated an appreciation of the work of the authors in the preparation of the papers, and testified to the value of the data contributed, as well as brought out a number of points of particular interest. These discussions are printed in their complete form below.

DESIGN OF FIRE TUBE BOILERS AND STEAM DRUMS, F. W. DEAN

DISCUSSION

W. F. KIESEL, JR.[1] (written). The ills of boilers and some remedies, as described by the author, are worthy of considerable thought. The remedies proposed seem to indicate a general rule, that is, to distribute unavoidable distortions or deflections over as much space as possible, thereby avoiding concentration of strains in isolated locations, at which points, due to stresses approaching or exceeding the elastic limit, detailed fractures will occur.

The author has pointed out possibilities of change in design which tend to distribute the distortions. Distortions due to varying pressures can generally be eliminated in this manner. Changes in shape due to temperature must receive careful consideration by the designer, who usually estimates the possible extent of the distortion and utilizes the best available means to counteract the resultant strains within sufficient limits of stress per square inch. He also makes it a point to leave as much freedom as possible for the parts to expand and contract, realizing that such obstruction to expansion and contraction creates undesirable strains in the plates.

It is undesirable to introduce holes or stays unnecessarily for which reason the writer cannot agree with Mr. Dean in his recommendation to eliminate dished heads. It is true that some such heads have failed, but in connection with these failures there is chance for grave suspicion that either the metal in the head has been damaged, or that the design of the head was faulty. A well-made and properly-designed dished head will give no trouble, and thousands of them are in use. A dished head should have sufficient metal in the cylindrical flange to resist the pull of the spherical dish. Another important feature is the transition radius at the circumference of the flange.

The calculations as given by Rankine and others are not easy to handle by ordinary inspectors and laymen, but the engineer has no difficulty in properly designing a dished head. The formulation of rules for the use of inspectors must, necessarily, be simple. Such rules are, therefore, inclined to err on the safe side, and result in dished heads which are stronger than necessary.

For reasons given, we believe that, within prescribed limits, dished heads would have preference for small drums and boilers. This permits eliminating unnecessary stays and rivet holes, which stays at the same time oppose natural expansion and contraction due to heat and thereby create unknown internal stresses in the material.

THOMAS E. DURBAN There is one point in the paper I would like to bring out, and that is in reference to the recommendation that all holes be drilled through the solid. Our experience is that in drilling a number of plates, such as a horizontal boiler, with butt straps, it is impossible to drill them through the solid clear through and make as good a job as you can make if a pilot hole is punched, and the drill run through the pilot hole. As a matter of fact, in the case of a multitude of plates drilled together, it is impossible to run the drills through with the rapidity necessary in order to do the job quickly and not have the drill run.

THE AUTHOR. Concerning Mr. Kiesel's view of the safety of dished heads, it is of course to be expected that mine would not be acceptable to everybody. I was not aware that the proper method of designing safe dished heads had been determined and hardly thought it likely to be. My view was therefore that it is best to have heads that are unquestionably safe.

In regard to Mr. Durban's view, I feel that his opinion would not be shared by all boiler makers, for there are some who make a practice of drilling rivet holes, and who, in fact, have no punches capable of punching holes through anything but plate about thick enough for boiler uptakes. I have always felt that the machines used for drilling holes in boiler plates are flimsy and unstable, and I think that in order to drill plates properly it is merely necessary to have machines that are of good stiff design. When such are used I feel certain that the difficulties mentioned by Mr. Durban will not exist.

THE HEAT INSULATING PROPERTIES OF COMMERCIAL STEAM PIPE COVERINGS, L. B. MCMILLAN

DISCUSSION

LEONARD WALDO. I doubt whether even the author is aware of the great importance of his timely discussion of this subject. Of late years there have developed new uses for steam under pressure developing mechanical power at distances from the point of steam generation; for instance, the application of steam to the atomization of oil in open hearth furnaces, where it is necessary to retain the full pressure power of the steam, and where it has usually to be conducted through transmission lines over long distances. In this use it is essential that no loss of terminal pressure power takes place from heat losses in the steam with consequent pressure lowering at the colder steam exits.

In this paper the very high insulating materials are not referred to. Infusorial earth, used at times in the insulation of large furnaces, has a transmission power of $\frac{1}{4}$ that of the magnesia used in the tests described. There are better insulating materials considered from the insulating standpoint alone than those mentioned in the paper, but the ability to transfer from the data given here to the conditions of practice in individual cases is of great value.

[1] Assist. Mech. Engr., Penna. R. R.

F. M. FARMER. At the Electrical Testing Laboratories we recently completed a series of tests of this character on about thirty pipe coverings. We used the Stott method, which I think the author will agree is of the same accuracy as the method he used and much simpler, although the matter of making extended tests is a question of having the necessary large current available. A 2-inch bare pipe heated to a temperature of only about 350 deg. required approximately 1500 amperes, showing that a large current source is one of the obstacles to the use of this method for the larger sizes of pipe.

Only one of our coverings can be assumed identical with one of those tested by Mr. McMillan. In that one case we obtained the same so-called efficiencies within about one per cent. However, our actual values on both the bare pipe and the covered pipe were of the order of 10 or 12 per cent higher, a difference which we ascribed to the size of pipe used. We made the bare test on a 2-inch pipe and the covered test on a 3-inch pipe.

Dr. Kennelly in some of his work on heat losses from very small rods quoted Professor Boussinesg as concluding that the connection losses varied inversely with the square root of the diameter. If that law holds for large diameters, it would fully account for the difference between the author's results and ours.

HERBERT N. DAWES. This paper indicates much careful work and observation and contributes some very valuable data.

The question of the permanency of the various coverings is touched upon but lightly. Apparently no tests have been made upon coverings after they have been in actual service for some time. Some tests of this sort were made by Prof. C. L. Norton several years ago at the Massachusetts Institute of Technology. Some sections of 85 per cent magnesia covering which had been on a steam line in a tunnel for eight years were tested and found to be a fraction of 1 per cent more efficient than the new covering of the same make and thickness. This difference was probably due to the extreme dryness of the sample which had been so long in use. Other coverings which had been in service for a number of years were tested and their efficiency had dropped varying amounts.

In twenty years' experience with insulating materials of various kinds, I have seen some coverings which have deteriorated very much after a few years' service, in some cases so much so that there was not enough material left upon which to make any test.

The temperatures frequently used to-day in superheated steam lines are sufficient to drive the water of combination out of asbestos fiber, and of course make the use of wool fiber impossible. The effect of these temperatures on the asbestos fiber is to cause a breaking up and powdering, particularly in the presence of pipe vibration. Another practical point that should be considered is the effect of moisture from steam leaks or submersion. Along this line I have found that coverings of moulded form, such as 85 per cent Magnesia, have been less damaged at least as regards future efficiency, than those made up of wool or asbestos fiber. I have therefore to take issue with Mr. McMillan on his statement that fibrous coverings are the more permanent. They certainly do not compare favorably with 85 per cent magnesia covering.

Another point of great importance to be considered in selecting a pipe covering is the possibility of re-use, either for application in the same sectional form or in the form of plastic. Fibrous coverings, for instance, if once badly damaged, cannot be used again. On the contrary, some of the moulded coverings such as 85 per cent magnesia can be pounded up and reapplied as plastic, and are thus more or less permanent.

A factor affecting the efficiency of a pipe covering is the care of application. It has been found that a covering carefully applied and the same covering applied in a casual manner may show a difference of over one per cent in efficiency.

The proportion of surfaces to be covered which must be treated with a plastic rather than a sectional covering is a factor of interest. With 85 per cent magnesia covering, the plastic is of the same composition as the sectional, and hence of practically equal insulating value. When other types of covering are used, particularly those of a fibrous nature, the plastic has to be of a different composition, and this affects the efficiency of the entire insulation equipment in a substantial manner.

As the difference in nonconducting efficiency of several of the better coverings as shown by Mr. McMillan's figures is very slight it seems some of the practical points I have spoken of are really of more importance in determining the kind of covering to use on most steam installations.

A large number of the coverings tested by the author seem to be of the manufacture of one concern. There are at least five different makes of 85 per cent magnesia covering on the market, and in these tests but two were measured.

It would be interesting to know whether the author has made any investigation of the temperature drop in super-heated steam lines at different velocities. Some reliable information on this subject would be most useful in solving insulation problems in connection with superheated steam insulation.

ARTHUR M. GREENE, JR. (written). Last year we performed experiments on 85 per cent Magnesia and Nonpareil High Pressure covering and found a slight advantage for the latter, as the author has found, but for our range from about 220 to 320 deg. fahr., we found a much smaller change in the value of k. Our results gave the value of k as a constant.

It must be remembered that if k varies with the temperature difference, the expression

$$Q = k \frac{\theta_1 - \theta_2}{x} A \; t$$

gives on solution values of k which is now not the coefficient of conduction but the value of $Q \; x \div (\theta_1 - \theta_2) \; A \; t$. This quantity may be used in computing heat losses if its value is known for different values of temperature differences. It is of distinct value, but it is not a true constant of conduction. The value of the constant might be found by using an expression of the form

$$Q = k_1 \, f \left(\frac{d\theta}{dx}\right) \frac{d\theta}{dx} A \; t$$

If this could be investigated, valuable information might be obtained.

$$W_1 = \frac{k \; (\theta_1 - \theta_2)}{r \; (\log_e r_2 - \log_e r_1)}$$

in which W_1 is the rate of heat flow per sq. ft. of pipe per hr.; k is the conductivity; θ_1 and θ_2 are the temperatures; r_1 and r_2 are the radii of the inner and outer surfaces of the pipe respectively, and r is the outside radius of the pipe, is apparently derived from

$$Q = k \frac{d\theta}{dr} 2\pi r$$

but it might be well to state the origin of the expression. I think the term r outside the bracket should have a subscript and should be r_2, and that W_1 should be W_2, since it corres-

ponds to the heat through the area at the outside. If it is the heat at the inside, r should be r_1.

The writer has not checked over the cost problems and monetary efficiencies, but would like to point out the importance of remembering that these results only hold for the assumed cost data and assumed rates of interest, depreciation, taxes and insurance.

It is hoped that the author may carry his investigations one step farther and use one and the same covering on from three to five different diameters of pipe, with say three different thicknesses of covering on each. There may be certain relations between the inner and outer surfaces at different radii which may affect the result. If this is not necessary, then the simpler methods used by Knoblauch or by Nusselt with flat disks of materials would be the better way to determine values of the quantity k.

L. R. Ingersoll[1] (written). I am very glad to note that the author has applied the mathematical formulæ for heat conduction in his paper, for by the judicious use of theory in connection with experimental results, a piece of work of this sort is made vastly more effective than otherwise. It is not practicable to cover by experiment all the possible variations of size, thickness, etc., which enter into a problem of this kind, and the use of such well-grounded formulæ as those of head conduction to fill the gaps left by experiment and to extend the results is eminently desirable.

As I have pointed out in a former paper (Eng. News Oct. 30, 1913) it is a little unfortunate that the engineers have adopted a unit for the measurement of heat conductivity which —because of its inconsistency in using two different units of length, i.e. the inch and (sq.) foot—makes it difficult to apply heat conductivity formulæ to any but the simpler cases. With the general adoption of the metric units, will come an incentive to a wider application of theory to experiment along these lines than has existed heretofore.

The Author. Replying to Dr. Waldo's remarks, the author believes that it would be highly desirable to have tests made on infusorial earth and other materials that are used in preventing loss of heat from hot blast stoves. However, it would be very remarkable if any of these were found to have four times the insulating value of 85 per cent Magnesia.

As Mr. Farmer says, the difference in size of pipe as tested by him from that used in the tests described might account entirely for the larger values of losses he obtained. This can be demonstrated mathematically. With 1 in. of covering the 5-in. pipe would lose only 85 per cent as much heat as the 2-in. and only 92 per cent as much as the 3-in., other conditions being the same. Therefore, his results are in almost perfect agreement with those in the paper.

In reply to Mr. Dawes, at the present time it is comtemplated to collect data on the durability of various coverings, by correspondence with those who have had them in use for a number of years.

The reason for not testing more magnesia coverings was the very close agreement of the two which were tested. It was decided then that magnesia covering made up properly would be about alike for all manufacturers, and the author considered that it would be a waste of time and money to test all.

In reference to the temperature drop in superheated steam pipes at different velocities, the author can only refer Mr. Dawes to the paper by Eberle, the reference to which is given in this paper. Eberle's results are probably the best yet published on the subject, but the conditions under which they were obtained were not varied enough to make them generally applicable.

Professor Greene's discussion referring to the factor k is of interest in a mathematical discussion. However, the fact that k has different values at different temperatures is not sufficient justification for saying that it is not the conductivity of the material in question. Conductivity is defined as being the rate of heat flow per degree temperature difference per unit area per unit thickness per unit time. k, as used in the paper, conforms to this definition, and the fact that it is not constant but varies with the temperature has already been demonstrated by Nusselt as explained in the paper.

Professor Greene is correct as to the origin of the equation giving W_1. However, since it applies to unit area, the term $2\pi r$ does not appear and the fundamental equation is

$$\frac{Q}{2\pi r} = W = k\,\frac{d\theta}{dr}$$

The subscripts are correct according to the definitions given to the various factors.

The objection to the methods used by Knoblauch and Nusselt with flat discs instead of pipes as the covered surfaces is that such methods do not permit of the testing of commercial pipe coverings. But where the conductivities of the materials used have been accurately determined by those methods, the results may be made applicable to actual pipe covering conditions, as explained in the mathematical treatment of the subject.

The great truth of Professor Ingersoll's remarks on the advantages of the metric units over the more unwieldy ones now so commonly used by engineers will be appreciated by all those who have attempted to apply theory to the more complicated physical phenomena.

CIRCULATION IN HORIZONTAL WATER TUBE BOILERS, Paul A. Bancel

DISCUSSION

George L. Fowler said that a few years ago he had made some investigations of the circulation in locomotive boilers, and had also watched the apparent circulation in some very finely constructed models of locomotives; and his whole experience led him to be very cautious about accepting the indications of circulation in a model.

He understood that the experiments with the model under consideration were made at atmospheric temperature. If the evaporation per square foot of heating surface were to be the same as in a full-size boiler, naturally in a boiler working under 100 or 200 lb. per sq. in. the bubbles would be smaller than they would be in a model boiler, on a proportion of perhaps 1 to 4 in diameter.

Now, the water spaces in a model boiler are small also, and proportionately small in comparison with the full-size boiler of the same general dimensions and proportions, and he thought the whole gist of the argument simmered down into what the author stated, that the rate of circulation is dependent upon the size of the bubble of steam passing through the boiler. Therefore the circulation would be very much more rapid in the model than in the full-size boiler. He originally had the idea that the circulation in a locomotive boiler was torrential, especially as investigation had shown that the rate of evaporation in the firebox was very much higher than it was in the tubes.

In his own experiments he had started with the idea he would have to provide for the measurement of a circulation of

[1] Assoc. Prof. of Physics., Univ. of Wisconsin.

400 or 500 ft. per sec., but after thinking the matter over, mentally came down to providing apparatus for measuring 125 to 150 ft. per sec. At about this time he saw an advertisement, in the form of a large inverted globe partly filled with water with air bubbles coming up through it. He timed these bubbles and found that they rose at a rate of about 4 ft. per sec. He reasoned that steam bubbles should not come up through water any faster than these air bubbles did.

By the time he started his investigations he had arrived at the conclusion that if he provided for about 8 or 10 ft. per sec., he would be about right. As a matter of fact, the highest circulation he got in a locomotive firebox, when the evaporation was of the rate of 12 lb. of water per sq. ft. of heating surface per hour, was about 2 ft. per sec. The condition of a locomotive boiler seems to be that we have a slow, gradual movement through the shell backwards and then some agitation, and the flowing up, on the inside sheet, and then a downward movement on the outside sheet, but the general tendency is back, and just about enough movement to supply evaporation, apparently.

Some recent work on full-size boilers corroborated that statement, he said. The temperature in the lower corner of the water leg at the front was never within 75 deg. of the temperature of the steam when the engine was working full. Perhaps it came within 50 per cent, but it was markedly below, whereas with that slow movement of water back through the firebox, in the back corner of the water leg down close to the mud ring, there was a temperature up to that of the steam. These experiments led him to be rather skeptical in regard to accepting any demonstrations from a model, where necessarily the water spaces are quite limited and the steam bubbles correspondingly large. That there is a general correspondence between a model demonstration and a full size boiler demonstration he did not doubt, but from a quantitative standpoint, he questioned the value of the model investigation described.

William Kent. The tests of the model boilers described by Mr. Bancel are interesting, but it is difficult to draw any conclusions from them that will be of any service in the design of full-size boilers. Some years ago the speaker had occasion to assist in the tests of a quarter-size model of a Rust vertical water tube boiler. The tubes were about 1 in. diameter and 5 ft. long. The ends of both upper and lower drums were fitted with disks of plate glass, and to the bottom end of each tube a slender white thread was attached by means of a fine wire so that the threads would show the direction of the circulation. Some surprising results were obtained. When the boiler was steaming at a moderate rate some of the tubes of the front bank would be carrying water upward while others were carrying it downward, but the upward currents would often change from one tube to another without any apparent cause.

Experiments on model boilers of the inclined water tube type cannot reproduce the conditions that exist in a full-size boiler, for in the latter there is at least 5 ft. distance between the water level in the drum and the highest point of the bottom row of tubes. This would make a difference of pressure of over 2 lb. per sq. in. if the water was at rest, and a greater difference if the water was in motion, on account of the frictional resistance of the upward passage. This extra pressure in the lower tubes would tend to prevent the generation of steam in them, and it is probable that they carry only water which is at a higher temperature and pressure than that in the overhead drum, and which begins to generate steam only when it passes into the region of lower pressure in the upper part of the headers and in the drum.

John C. Parker. The author says: "In addition, it is generally believed that a high velocity of circulation will retard scale formation and thus indirectly reduce the resistance to heat transfer and prevent overheating of the tubes." Some seventeen years ago I visited our late President, Prof. R. H. Thurston, at Cornell, and made the statement to him that the circulation was so rapid in our boiler that it would carry the solid matter along like dust in a strong wind and prevent scale formation. He said it would carry the insolubles, but not the solubles, and it turned out that way. Our experience has been that scale forms wherever the steam is made, and that if there is any carrying along of the scale it is after it is formed and then cracked loose.

It is quite desirable in designing a boiler to get the most rapid circulation possible. The strongest flow would be secured if we could get nothing but steam in the up-pass and nothing but water in the down-pass. Evaporation is secured in the horizontal tube by extending that long enough.

Arthur M. Greene, Jr. wrote that the experimental part of Mr. Bancel's paper was interesting in its qualitative nature but he could not see where quantitative results could be obtained from it.

In the rates of radiation given in the first paragraph, the author does not state the assumption on which the results are obtained. If the Steffan-Boltzmann law has been used with no corrections it should be so stated.

The formula $v = \sqrt{2\,g\,H}$ is only true for a free fall. The true formula is

$$v = \sqrt{\frac{2\,g\,H}{1+z}}$$

in which z is equal to the sum of loss coefficients and is quite large in the case under discussion. The formula

$$v = \phi\sqrt{\frac{v\,h}{A}}$$

is not a balanced equation of time and in distance unless ϕ contains these elements, ϕ must be variable and the variations must be great.

Ambrose B. Dean demonstrated a glass model to the scale of 1/18 of a water tube boiler in working condition, showing the action in the bank of tubes and the drum. He said he had not made any accurate determinations from this model but hoped to do so at some future time.

A. A. Cary agreed with Professor Kent as to the small amount of reliable information regarding circulation to be gained from the use of models, although he thought a glass model might give very useful suggestions. He said he had considerable experience in testing with glass models, and also testing with full-size boilers, and he had received a great many useful suggestions from glass models which he had verified in the full-size boiler. He thought the glass model would show the underlying principles, but beyond that care should be exercised in drawing conclusions from it.

The Author. In reply to the members who have questioned the value of experiments on models, the author wishes to point out that in the solution of problems involving the flow of fluids, that is in hydrodynamics and aerodynamics—the use of models is invaluable.

The fundamental data of the subject of aerodynamics has been derived very largely from experiments on models. Langley's figures for model planes, modified by Lilienthal's experiments, provided the information from which the earliest flying machines were constructed. The work of Lanchester, Bryan and Eiffel was based largely on experiments with models.[1] As to ship propulsion, the testing of models of ships has been carried on for years.

The circulation in a water tube boiler is a highly complex problem, involving not only a complicated circuit with tubes working at different loads, discharging into a common header, but also the movement of two fluids, steam and water, at dissimilar and varying velocities. In quoting results of researches with a model, the writer made no attempt to predict or state the circulation or the pressures influencing circulation in the various types of actual boilers, confining his remarks to the model. His knowledge of the laws of similitude connecting a model water tube boiler and its prototype when circulating non-homogeneous mixtures of steam bubbles and water, is not sufficient to permit of such predictions, but he sees no reason why the results obtained should not be similar in kind, at least, to those to be obtained in an actual boiler. He does not believe that "the circulation of all boilers is good enough," as stated by Professor Kent, first, because cases of tube failures, some of which caused loss of life, have occurred where the tubes were new and it was known that they were free from scale; second, because boiler loads and furnace temperatures are constantly increasing, and third, because the investigations undertaken indicate that present designs do not conform in several respects to the necessary requirements for the maximum delivery of water through the tubes nearest the fire.

Replying to the point raised by Mr. Fowler regarding the size of the bubbles in an actual boiler as compared to those in the model, experiments have shown that the size of the bubbles seems to be independent of the pressure, depending on the conditions of ebullition and the character of heating surface. See experiments on a small boiler in which pressures up to 12 kg/cm were carried, by M. Emanaud, Le Génie Civil, January 6, 1911.

Professor Kent states that "it is doubtful whether there is any steam at all in the lower tubes." The 2 lb. pressure calculated by Professor Kent would amount at 200 lb. boiler pressure to about 0.8 deg., and for every pound of steam formed by the "water bursting into steam" in the drum, there would have to be about 1000 lb. of water passing through the tube. For a tube working at 200 lb. of steam per sq. ft. per hr. evaporation, this would call for approximately 10 cu. ft. flow per second or a velocity through the tube of about 150 ft. per sec. Experiments show that the velocity of water entering a tube is on the order of 5 ft. per sec.

In reply to Mr. Parker, what we are after in boilers is to pump the most water through the bottom tubes. The water comes into the tubes zero per cent rich in steam and 100 per cent rich in water. It should come out as rich in water as we can make it, and we then have less chance of burning and blistering the tubes.

The statement made by the author regarding scale formation and referred to by Mr. Parker was not advanced except with reservation. Experimental evidence on the effect of water velocity on scale formation not only in boilers but feed heaters, evaporators, condensers and similar apparatus would add to the value of the present discussion.

Professor Greene has pointed out that ϕ in the equation in Par. 6 "Must be variable and the variation must be great." In fact, the variation is so great as to make the expression practically useless, and it is for that reason in part, that the model experiments were undertaken. The conditions as to the existence and effect of slip have not heretofore to the author's knowledge, been investigated. In the classic lecture on circulation by Mr. Babcock at Cornell University, the speed of circulation was calculated neglecting resistance, by the use of the equation $v^2 = 2\ g\ H$; H being determined by assuming an homogeneous mixture of steam bubbles and water and freedom from slip throughout the circuit.

Mr. Dean's model shows the difference in the quality of the mixtures discharged from the lower and upper tubes. The lower tubes discharge more nearly homogeneous mixtures containing small bubbles. The upper tubes discharge large steam bubbles intermittently; the circulation is reversed even, when the area at the entrance to the drum is reduced.

[1] Baristow, The Laws of Similitude, Aeronautical Society of Great Britain, Feb. 2, 1913. See Engineering, London, Feb. 14, 1913.

PERFORMANCE AND DESIGN OF HIGH VACUUM SURFACE CONDENSERS, Geo. H. Gibson and Paul A. Bancel.

DISCUSSION

Leo Loeb. The authors state it may be assumed, in the light of evidence given in the appendix, that the total heat transfer is a function of the first power of the temperature difference, and not of a fractional power as suggested by Loeb and Orrok, but the appendix contains no evidence to support this claim. However, in discussing certain data, they state it was concluded from these tests "that the coefficient was constant if the total heat transfer was assumed to vary as some fractional power of the temperature difference rather than unity." This is a misstatement, as there was no assumption of total heat transfer as an exponent of the temperature difference. It remains a fact, determined from many experiments, that the total heat transfer is proportional to a power of the temperature difference. This power is not necessarily less than unity, although in some of the tests I have examined of the transfer of heat from steam to water under practically air-free conditions the coefficient was less than unity. However, in the case of heat transmission from condensing steam and air, the coefficient is usually greater than unity. The quotation should therefore be recast somewhat as follows, "and from these it was shown the total heat transfer was proportional to some power of the temperature difference, usually less than unity, hence the coefficient for one rate of flow would be constant."

The manner in which this law was investigated in the experiments referred to was to introduce water at a reasonably low temperature into a short-pass heater, keeping the steam temperature as nearly constant as possible. The outlet temperature was carefully noted after a test of reasonable duration, and then the water was re-introduced at the inlet of the heater at the temperature at which it appeared at the outlet during the previous test, and so on, carrying this up along a true temperature gradient. When the gradient was plotted it was in exponential form, and not in logarithmic form as would be required by the law of heat transfer proportional to the first power of the temperature difference.

The authors call attention to the fact that in the tests on the Bureau heater, the steam temperature varied only 2 deg. In the experiments on the apparatus, we tried to keep the temperature constant, but the construction of this particular heater was such that with high rates of water flow there was a small condenser action and a slight drop in pressure within the shell making it almost impossible for the temperature to be kept absolutely constant.

The authors further state it is reasonable to expect that if the variation in temperature difference were obtained entirely by varying the steam temperature only, the exponent would be found to attain unity. Now in marine feedwater heaters, and in closed heaters generally, the object is to attain a standard of temperature; and while we did investigate the fact of varying pressure, and while the authors have taken three points from these tests and found them alike on a straight line with a slope of unity, that is simply a coincidence. The indisputable fact remains that a long series of experiments on single tube and commercial marine feedwater heaters shows the temperature gradient to be exponential, and no reasonable expectancy on the part of those who have not "lived" with the apparatus will change the fact.

The curves in the writer's paper to which the authors refer were plotted from heaters in which we were forced to use a different method of obtaining the temperature gradient, and while it does introduce a little more complexity, still these are the facts, and we must abide by them.

R. N. Ehrhart. The first part of the authors' paper consists in the collection and tabulation of results obtained with various surface condensing plants. As such, it is interesting. However, we do not believe that curves derived from the performance of various sizes and types of condensers of different manufacturers can be consistently grouped in curves to show typical results. It is quite evident that one style or design of condenser might give certain characteristics which could be successfully shown graphically, but to take all other types and put them on the same curve sheet with the expectation of getting something that is really of great value is impossible.

The latter part of the paper is based on misconceptions of the performance of modern condensers. For example: The performance of the condenser as shown in Fig. 10 is not at all in line with that given by modern design. In days gone by, we used condensers in which there was little rise in temperature in the lower pass, but condensers of to-day, if properly designed, will have about 60 per cent of the work done in the lower pass. It is obvious that this should be so. If the condenser is perfectly scavenged of air, the greatest temperature head exists in the lower portion of the condenser, which, in the contra-flow type, is nearest the end of the condensation zone, and in the beginning of the water circulation zone. The use of a hydraulic air pump makes it easy to get such results without the use of external coolers.

The authors attempt to show that there is a compression of the air in the condenser, and that this necessitates a lowering of the temperature of the steam space. Such a phenomenon need not exist at all. Where a hydraulic air pump is employed, using water of the temperature of that delivered to the condenser, the compression can all take place within the pump itself; that is, the readjustment of vapor and air pressures does not need to take place in the condenser.

The authors dwell on a suggested form of zone condenser, in which the lower pass uses little water and consequently little power is there absorbed. As pointed out above, the modern condenser does most of the work in the bottom pass, so that the suggested form of zone condenser, instead of accomplishing something desirable, turns out to be about the most undesirable modification that we could make in a modern condenser. Therefore, it can have no place in modern condenser practice.

George H. Gibson (written). In none of Mr. Loeb's tests did he work with a constant fixed water temperature and different steam temperatures; and that would be necessary in order to eliminate the variations that might be due to the water temperature, per se, or else the influence of the water temperature must be allowed for. In the tests described by Loeb, the influence of water temperature was ignored. It is therefore improper, on the basis of his tests alone, in which the variations in temperature difference were obtained by varying the water temperature, to state just what precise effect temperature difference by itself had upon the rate of transmission.

In reply to Mr. Ehrhart, the condenser tests presented are those to which we had access in publications and in reports by manufacturers and users. If there are in existence tests showing no temperature drop caused by enrichment of the air mixture, we would like to examine them. We concede that by putting on a supplementary condenser the mixture can be drawn out of the first condenser before the effects of air are apparent, that is to say, before steam condensation is completed, in which case only such drop of temperature as might be due to the steam flowing through the tube bank would exist. With the tubes properly arranged, this temperature drop would be comparatively small, at least at low vacuums and the attending low specific volumes.

However, if the mixture is to leave the tube bank at nearly its original temperature, a considerable percentage of the steam will remain to be compressed or condensed in the air pump. The objection to using the air pump for steam recompression is self-evident, while if a hurling water air pump is used in order to condense the steam, the temperature of the hurling water will be raised and the efficiency of the air pump impaired. If a large amount of water is used in order that the temperature rise in the pump may be small, a heavy expenditure of power to drive the pump will be encountered. Water handled by the circulating pump may have a temperature rise of 10 deg. fahr. and may be pumped against a head of 15 ft., whereas water handled by the air pump may have a rise of only a few degrees and the head pumped against will be 150 to 250 ft. To condense a pound of steam, 50 to 75 times as much power is taken by the air pump as compared with the circulating pump, for which reason it is not a good plan to allow much of the steam to pass to the air pump, which is what Mr. Ehrhart's claims really imply.

Paul A. Bancel (written). Replying to Mr. Ehrhart, the performance of the condenser from Josse's tests was cited to show conditions existing in a small condenser working at moderate vacuum with a considerable air leakage. The same conditions are noticeable, it is maintained, in large vacuum condensers even with small air leakage and large pump capacity (irrespective of the design of the pump), because due to its large specific volume, the steam cannot penetrate into the condenser and, due to the great rarification, the air cannot be removed except after some preliminary compression and concentration in the condenser.

The condition of temperature equivalent to pressure alleged by Mr. Ehrhart precludes any leakage whatsoever or else an air pump of such capacity that the air can be removed at immeasurably small partial pressure, together with an unavoidably large volume of steam.

With a *small* condenser heavily loaded under summer conditions when the vacuum is low and with a large air pump of the hurling water type using a comparatively large quantity of water and corresponding steam condensing capacity, most of the surface in the condenser can be brought into active working.

While it is possible to design a *large* condenser and attach

a pump of sufficient capacity to secure equally good results under summer conditions, under high vacuum conditions in the winter the proportion of active surface will fall off and the inactive zone which might originally have comprised a small percentage of the surface will now comprise a very large share of the tubes. High vacuum condensers recently installed in connection with 30,000 kw. turbines in several large cities and equipped with air pumps of the hurling water type show comparatively low average heat transmission coefficients under conditions of high vacuum and cool or cold water.

The condition of 60 per cent work in the lower pass of a condenser coincides in every case known to the writer with a design in which openings or steam lanes have been provided to pass the steam down to the lower tubes, thus allowing the steam to by-pass groups of tubes in the top of the condenser. The resulting average coefficients of heat transfer are low, as would be expected, since the surface is more or less out of active use. The active tubes instead of being concentrated in one pass of the condenser are now scattered throughout the shell wherever the steam has easy access and their location is not indicated by thermometers placed in the main water connections or water boxes.

Replying to Mr. Loeb, the authors' statement was to the effect that the experiments were not sufficiently complete to warrant conclusions regarding the relations of the heat transfer to the temperature difference. The temperature difference depends on both steam and water temperature, and to be conclusive experiments should be made in which the mean water temperature is maintained constant and the difference varied by changes in the steam temperature only, in order to eliminate the effects of water temperature.

HIGHER STEAM PRESSURES, ROBERT CRAMER

DISCUSSION

WILLIAM KENT (written). This paper contains some interesting figures of the gain in steam engine efficiency that may be obtained by increasing the steam pressure up to 600 lb. per sq. in. absolute. They supplement very conveniently some figures for the efficiency of the Rankine cycle which I calculated recently for pressures up to 250 lb. per sq. in. and superheat up to 300 deg., and which will be found on p. 1091 of the 9th edition of my *Mechanical Engineers' Pocket Book*. Taking the figures corresponding to 29 in. vacuum:

	Superheat, deg.						
	0	50	100	150	200	250	300
Press. lb. Absolute.	Efficiency of Rankine Cycle, per cent.						
200..........	32.2	32.3	32.6	32.8	33.1	33.4	33.8
225..........	32.7	32.9	33.1	33.4	33.6	34.0	34.3
250..........	33.2	33.4	33.6	33.9	34.1	34.5	34.8
Superheat corresp. to temp. 600 deg...				113.4	132.7	155.2	182.5
300..........			34.0	...	...	...	34.5
400..........		(Mr. Cramer's	35.3	...	...	36.1	
500..........		figures.)	36.4	...	36.7		
600..........			37.0	37.3			

Taking 225 lb. per sq. in. and 200 deg. superheat, corresponding to a temperature of 591 deg. and a Rankine cycle efficiency of 33.6 per cent, as about the standard of the most recent practice, the improvement that may be made by using a pressure of 600 lb. and a temperature of 600 deg. is (37.3-33.6) or 3.7, or 11 per cent. of 33.6 per cent. In order to obtain this gain it will be necessary to build stronger boilers than we now have, to use economizers to reduce the flue gas temperature, and to take extra precautions against steam leakage. These improvements are quite within the range of practicability, and it may be worth while to make them to gain a 11 per cent gain in efficiency, especially in locations where fuel is expensive and in plants having a high load factor.

Mr. Cramer says that it is possible to increase the effectiveness of the heating surface by proper design, and that modern boilers show an evaporation per square foot of heating surface twice as high as was customary only a few years ago, at the same time realizing a better efficiency than formerly. It does not appear that the improvements in rate of driving and in efficiency at high rates of driving have been due to any changes in the design or proportions of the heating surface; they have been due to greatly enlarged combustion chambers, mechanical stokers, and control of the air supply according to the indications of gas analyses. The highest efficiencies have been obtained with many different forms and proportions of boiler, and no evidence has yet been obtained that any new form of boiler will give greater effectiveness per square foot of heating surface than the forms of boilers that were built forty years ago.

R. J. S. PIGOTT. This interesting paper has presented the theoretical side of the question rather more strongly than the practical side. The sources of loss, especially in the turbine, have been passed over perhaps a little too lightly.

Those of us who have been interested in turbine designing for the last few years have noticed the very marked difference in the efficiency ratio of the various stages, between high and low pressure end of the machine. We know that the high pressure stages are very much less efficient. For instance, in a turbine working at 200 lb., with 100 deg. of superheat, the efficiency of the first stage is possibly 55 per cent or a little higher, depending upon the conditions, and that figure increases as we reach the lower stages, finally reaching 85 per cent, or even more, in the low pressure end.

The average efficiency ratio is ordinarily 70 to 75 per cent, including generator losses. The figure quoted by Mr. Cramer, of 77 per cent, must be quoted for overall efficiency, including generator loss. The actual efficiency of the Interborough Rapid Transit Company's turbines is over 80 per cent, if the losses to the generator are not considered, representing a high pressure efficiency of 70 per cent, and in the final stages somewhat over 90 per cent.

It is a fact that the efficiency of the stages of a turbine depends chiefly upon the density and condition of the steam, other conditions being equal. The reason for such low efficiencies in the high pressure stages is the high friction loss due to high steam density, and in the case of turbines running on saturated steam, on account of the additional friction due to the moisture. It is certain that if pressures are increased, the high pressure stages are going to become less efficient,—more especially as in substituting pressure for superheat, we are increasing the amount of moisture developed in the turbine and advancing the dew point to higher stages. In other words, the efficiency of each stage will be somewhat decreased, due to the presence of a greater quantity of moisture.

The author's expectations of the efficiency closely approximating present efficiency would not be reached with actual turbines. It is quite evident from our experience with up-to-date turbines that we cannot get very high efficiencies with the very dense steam to be expected.

Another point from the practical side is that of steam piping and pipe joints. It is generally felt that the best joint is one in which there is no gasket. Very good success has been made with ground joints, but the character of workmanship and pipe construction required for the ground joint is almost too high for ordinary construction and cannot be ob-

tained in the average plant. Therefore the forms which require metallic, or asbestos, or other soft gaskets, must be used for these temperatures and pressures, and there is trouble enough already with 200 lb. pressure.

In the plants of one large western company, the joints are made by fusing the edges of the lap flanges with the acetylene torch, so as to avoid gaskets. This, it seems, is the first step in the change that would be required for higher pressures. The next step would be to abandon flanges almost entirely, and weld the pipes in place, without joints. We are now using large quantities of welded material under very severe conditions. With the degree of skill now developed, satisfactory welding could be readily accomplished in the field. It would mean the substitution of a welding gang for steamfitters, on the larger work.

G. I. Rockwood. In regard to the facility of making pipe joints, I have been rather surprised, in working out the problem of making pipe union joints out of ground bronze seats, to find what a poor job of grinding is usually done. If the grinding is done properly, as I find it can be done with a properly developed machine, the joint will stand all pressures up to 10,000 lb. per sq. in., and the union will burst before it will leak.

Pipe unions will probably replace flanges in the larger sizes, and if higher steam pressures are to become at all general, the practical requirements of pipes, built in sections rather than welded together, will call for pipe unions properly made.

R. H. Rice. The subject of utilization of higher steam pressures in motive power apparatus has been before the designers of such apparatus for some time. The most active proposal in that direction was made, I think, by Mr. Faraday of England, some two or three years ago, and a great deal of investigation on this subject has been stimulated.

The author has very clearly set forth the theoretical possibilities involved in the use of higher pressures. The practical consideration is that of temperatures. Several years ago the writer constructed and operated an engine utilizing a maximum temperature of 800 deg. Although this engine operated successfully, we find, in investigating the materials to be used for these pressures and temperatures, at 600 deg. practically all the materials we would ordinarily use in the construction of such apparatus begin to lose strength. Therefore, we are limited to that critical temperature, or else have to choose special materials, or, as a third possibility, must greatly increase the proportions of parts in order to keep down the stresses.

Expansion of pipes would also be troublesome at high pressures on account of the rather extreme thickness of the pipes and their consequent stiffness.

The effect on turbine design has been clearly brought out by Mr. Pigott. In addition to the difficulties in realizing the highest efficiency which he has pointed out there is the very important one of leakage. If we attempt to use very high pressures on the upper stages of turbines, we will certainly have to develop improved forms of vacuum.

All these considerations do not by any means indicate difficulties which cannot be surmounted; on the other hand we are fitted at the present time to undertake the development of apparatus to meet these conditions. A considerable amount of development work will be necessary, however, and the new conditions will give rise to radical changes in the design of power stations. For instance, it is obvious that if these expansion stresses in pipes are to be difficult, we should limit the length of the pipe as much as possible, which means putting the boiler and turbine, or engine, close together.

The question of higher pressures is entirely a commercial one. Assuming that the gains indicated in the paper, or even half of them, can be realized, can apparatus be constructed of such cost and placed in our power stations under operating conditions, which will involve operating expenses in such amounts that the total operating gain, counting interest on the investment, operating cost, and general liability, make the proposition a profitable one for our power stations?

Walter N. Polakov. The question of advantages of higher steam pressures may be regarded from two angles of view. One is purely a theoretical consideration, setting aside the commercial advantages, and the other, the commercial advantages under the present state of the art.

If the steam is used at high pressure, and saturated, the condensation will have very quick deteriorating effects on the blading of the turbine. This is one of the financial questions which ought to be primarily considered before it is decided whether at the present state of the art the high pressure is advantageous.

Another consideration is whether the added cost of construction of the steam vessel for the higher pressures will be warranted. Incidentally, in European practice, temperatures are not confined to 600 deg. fahr., but go up to 800, and in some cases to 1000.

Carl C. Thomas. In regard to turbine design for higher pressures, the high pressure stage would necessarily be of the impulse type, because of the otherwise extensive leakage past the ends of the blades with steam of such high density as that at 600 lb. The turbine would therefore seem to require an impulse high pressure stage, velocity compounded, probably followed by Parson's stages.

Professor Carpenter's tests on the White steam car showed that at high pressures very good economy could be attained, even with small reciprocating engines. An engine of the general type of the Westinghouse single-acting vertical engine, with the lower end of the cylinders closed so that a vacuum could be maintained, but fitted with an exhaust port like that of the Stumpf engine, might be very efficient for use with these high pressures.

D. S. Jacobus. The statement is made in the paper that standard boiler designs do not permit the construction for higher pressures than 200 lb. That is a little below the limit, because there are standard designs operating at good high overlaps over 300 lb.; 200 lb. is surely too low a pressure to set today as the limiting pressure for standard designs.

The Author. Professor Kent has pointed out that the improved boiler efficiency in recent designs is not due to any change in the boiler itself, but rather to the furnace. If the point is conceded that high efficiencies can be obtained with high pressure boiler designs, then whether the necessary changes are made in the boiler or in the furnace is immaterial. I concede that most of the recent improvements in boilers have been made in the furnace, and not in the boiler proper, and the most efficient boiler designs used to-day are practically the same as those of twenty years ago. The question brought up in the paper is, however, entirely different. If steam pressures as high as 600 lb. are used, it will be necessary simply from that point of view to change the boiler design, and as pointed out in the paper, to do away with large drums and a small factor of safety.

Mr. Pigott raises the question of efficiency of the high pressure stage in the turbine. In the first place, it will almost be impossible in large turbines to utilize some of the principles employed to-day. It will not be possible to carry the high steam pressures right into the turbine. As a matter of fact, in most of the present large turbine designs, with the exception of the straight Parsons type, there is a large drop in pressure before the steam enters the turbine proper; in other words, in the very first drop of pressure, a good part of the energy of the steam is converted into velocity. The steam after it leaves the first nozzle, has now to be utilized in a scheme of velocity staging, and in that respect the turbines for high pressure will be practically identical with the present types of turbines, but the velocity stage at the beginning will be carried out to a greater extent.

It is quite true that with high pressures, losses in the high pressure stage of the turbine will be greater, but it must be remembered that all the losses occurring in the individual stages reappear in the steam in the shape of added heat, because there is no other way of disposing of them. While this loss of heat decreases the efficiency of the high pressure stage, it is partly utilized in the lower stages. Of course the losses that occur at the high pressure end, say between 600 lb. and 200 lb., will not be fully recovered in the low pressure end of the turbine, but by proper design they can be recovered to a very great extent.

Regarding piping, in the western plants which Mr. Pigott mentions, they have a welded seam between the flanges. The strength of the joints is given by the flange bolts, and the welding is used merely as a seal, and that works out in practice very well. Of course it is necessary in case of repairs to cut the seal, but on the other hand most of the repairs in these cases are caused by failure of the gasket, and that is the very thing the welding avoids.

I do not mean to point out that it is not possible to depend on the strength of the weld. In high pressure design with which I have experimented and carried out a great deal of practical work during the last few years every joint is welded. I have tested welded joints with pressures between 9,000 and 10,000 lb. per sq. in. and have burst the tube, being unable to injure the weld. It is therefore possible to depend on the strength of the weld if it is properly made.

At higher pressures, it is possible with a pipe line less than 12 in. in diameter to supply all the steam necessary to operate a 20,000 kw. turbine, and from that point of view the question of strength of joints is disposed of, because it is certainly easier to make 12 in. joints and welds for 600 lb. than to make 18 and 20 in. joints for 200 lb.

Mr. Rice has pointed out that loss of strength of the materials occurs in temperatures higher than 600 deg. The paper does not advocate raising temperatures while increasing pressures. For that reason the question of the loss of the strength in the material at high temperatures is eliminated.

In reply to Professor Thomas, the unaflow design of reciprocating engine is specially fitted for the adaptation to high pressures. It is a remarkable fact that such knowledge as we possess today points to the possibility of realizing fully in a unaflow engine efficiencies given by theoretical considerations. Such engines, too, are much simpler and are also less bulky than other engines used on lower pressures to obtain the same results.

In the light of Doctor Jacobus' criticism, I must modify the statement that the present day boiler designs are not suitable for higher pressures than, say, 200 pounds. At higher pressures, however, say 250 lb. and over, standard boiler designs become expensive enough to offset all the gain which would otherwise result from the employment of these high pressures.

Boiler designs are possible which will utilize high steam pressures without necessarily increasing the cost of the boiler to such an extent that the theoretical gains are almost wholly wiped out. The question is not merely a theoretical one, although the paper attempts to present only the theoretical aspect, it is primarily an economic one. Most of the discussors concede the possible theoretical gains, so the question remains: Can high pressures be realized in practice, without involving such high charges, due to initial cost of installation, interest on the investment, repairs, and up-keep, that the theoretical gains are offset? It has been my contention that these extra expenses necessitated for high steam pressures are not high enough to offset the theoretical gain, even to a small extent. As the problems of design are more clearly understood, and are properly met, we will within a very short time see the general adoption of higher steam pressures, especially in large power plant work.

PROPORTIONING CHIMNEYS ON A GAS BASIS, A. L. MENZIN

DISCUSSION

A. G. CHRISTIE. The author has rendered a distinct service in presenting the derivation and application of the various formulae relating to chimney problems when considered on the basis of the gases handled. His methods are quite rational and could be applied readily if definite information were available on all the factors involved.

The writer had occasion a number of years ago to design some chimneys for large cement kilns which operated on the wet process. These chimneys had, therefore, to handle the hot gases from combustion of the coal, the steam from the drying of the raw material, and the hot gases given off when the limestone was reduced to quick lime. As the regular formulae were not readily applicable, an attempt was made to solve the problem in the manner Mr. Menzin outlines, but so many unknowns were involved that the final design was based as much on guesswork as on engineering data.

Engineering literature is distinctly lacking in available data on the performance of chimneys, particularly as regards what takes place in the chimney itself. The variations of temperature, density, and draft from top to bottom of the various types of chimneys are practically unknown. Hence the velocities and volumes in the chimney are also unknown. The effect of wind has not been worked out, particularly in regard to the air leakage into the chimney under heavy winds, to the cooling of the gases, or to the suction, if any, over the top of the stack. Some recent experimental work has shown that humidity has a very appreciable effect on the flow of air in pipes. It is, therefore, reasonable to expect that humidity in chimney gases, due to the combustion of the volatile matter of bituminous coal and oils, and particularly in the case of lignite, must also have an effect on the operation of the chimney.

The chimney of the power plant of the new Johns Hopkins University has been specially built with the particular object in view of studying certain of these problems, and some work along this line will be undertaken in the near future.

Mr. Menzin submits tables based on assumed gas volumes and velocities, but does not supply any experimental data to indicate which, if any, of these velocities gives the best performance, nor are his friction factors derived from actual stack performance. The value of the paper would have been greatly enhanced by the addition of these experimental data.

UNIQUE HYDRAULIC POWER PLANT AT THE HENRY FORD FARMS, MARK A. REPLOGLE

DISCUSSION

CLEMENS HERSCHEL[1] (written). The idea of utilizing that portion of the freshet river flow that wastes over the dam for increasing the head acting on the turbines, at those times suffering from a diminution of the normal fall (or from backwater), is not new. Experiments on an apparatus of this kind were made by M. Saugey, superintendent of the Chevres power plant, owned by the city of Geneva, Switzerland, as early as June, 1905, and perhaps earlier. His system was described in the *Zeitschrift des Verein Deutscher Ingenieure*, about 1907, and in other journals, and a pamphlet, without date, issued by the Société Hydro-Motrice of Geneva, describes these and later experiments.

The efficiency of the Saugey apparatus, in terms of water

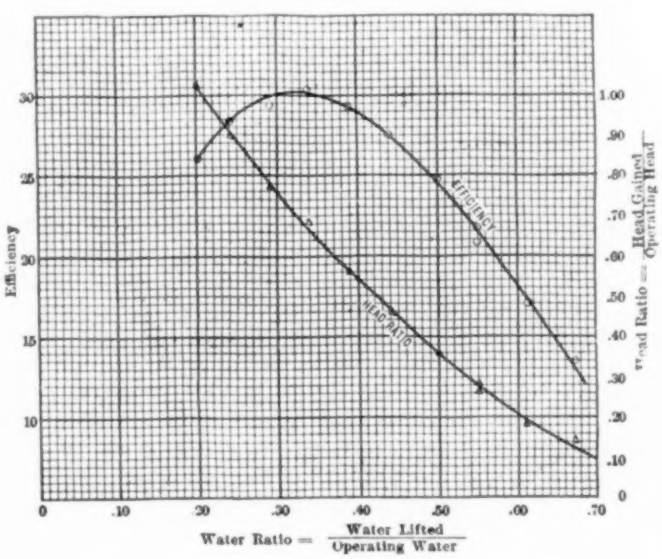

FIG. 1 RESULTS OF TESTS ON FALL INCREASER

lifted a certain height by means of other water falling a certain height, was about 3 per cent. This is poor, even for an apparatus that operates by induced currents of fluids. It gave the writer the impetus to accomplish something better, however, and in the *Harvard Engineering Journal*, June, 1908, he described a hydraulic apparatus for the purpose named above, which was called the "fall increaser." This had a maximum efficiency of 30.4 per cent.

A brief mention of the fall increaser, with an up-to-date design of a power house fitted with fall increasers, may be found in Transactions Am. Soc. C. E., November, 1915, in a discussion of a paper on Induced Currents of Fluids, by F. zur Nedden.

30.4 per cent. does not sound like a very high efficiency to turbine builders and others, but is believed to be very good for an induction current hydraulic apparatus.

There is nothing, not one word or figure, in the paper under discussion, to permit one so much as to guess at the mechanical efficiency of the "discharge accelerator." As one who has conducted experiments with both fall increaser, and also, to some extent at least, with a discharge accelerator, the writer has not much faith in the efficiency of the accelerator. The following is what he wrote in the *Harvard Engineering Journal*, June, 1908: "The fall increaser is not an ejector, and experiments made with an ejector form of throat-piece, and a $5\frac{1}{2}$-in. nozzle endeavoring to operate it, gave so poor results (efficiency) that there was no encouragement to continue along those lines." As the statement is made in the paper under discussion that the accelerator is not an ejector, it will be necessary to add that what above has been called "an ejector form of throat-piece," was similar to the discharge accelerator now shown. The difference consisted in this: The turbine discharge entered the throat-piece or mixing chamber through the annular area around the nozzle, instead of the operating water entering through the annular area, as in the discharge accelerator, with the turbine discharge blowing in

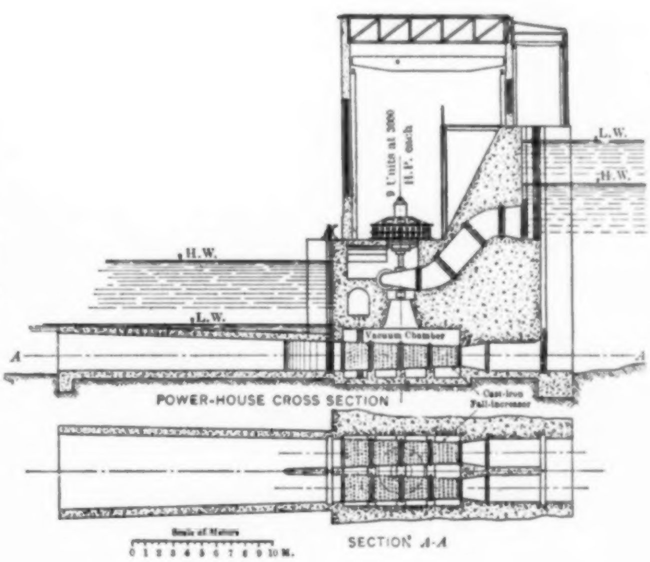

FIG. 2 POWER HOUSE WITH FALL INCREASERS

through the nozzle. There can not, in the opinion of the writer, be any material difference in efficiency between these two arrangements. The discharge accelerator arrangement is, however, the better one for regulating or varying the discharge of the operating water.

Here is another quotation from the June, 1908, article: "Nor does it seem to me that the forms of formulae found in the books and learned transactions for computing the work of ejectors, based on the assumption of an impact of the nozzle stream upon the water within the throat-piece, are based upon a proper assumption to produce a correct formula for representing ejector action. To my mind an ejector is only another form of negative pressure apparatus, in which suction causes the water to enter the throat-piece through a ring-shaped orifice situated all around the nozzle (in the accelerator, through the nozzle), rather than through holes fashioned in the throat-piece itself, and distributed over its whole outside surface, as in the fall increaser."

It might be thought that inasmuch as all these low fall turbine aids use freshet runs of the river to furnish the operating water, their efficiency is of no consequence; but as will be shown in detail, this is not so, unless at exceptional times; at the Henry Ford Farms the times called *e*, which last only, as one may judge, for certain set periods of hours during the

[1] 2 Wall Street, New York

year. From an experience of seven years in designing these plants for river situations of all kinds, the writer can state positively that the mechanical efficiency of the apparatus is of great importance; and so is the regime or character of the river on which the fall increaser is to be used.

It is all a question of kilowatt-hours produced by the fall increaser in the course of an average year's run of the river, set off against the construction cost of the fall increasers; and as one may or may not pay too high a price for a cube of gold, so fall increasers may or may not according to their efficiency be of economic value. They have this in their favor, that their product is of annual recurrence, forever; while their construction cost (operation and maintenance are negligible quantities) is incurred but once. As a numerical example and to fix ideas: In a case examined some years ago, when the fall increaser was as yet new, the annual product of the fall increasers would have been 153 million kw-hr. in an average year, delivered at times of high water and low fall,

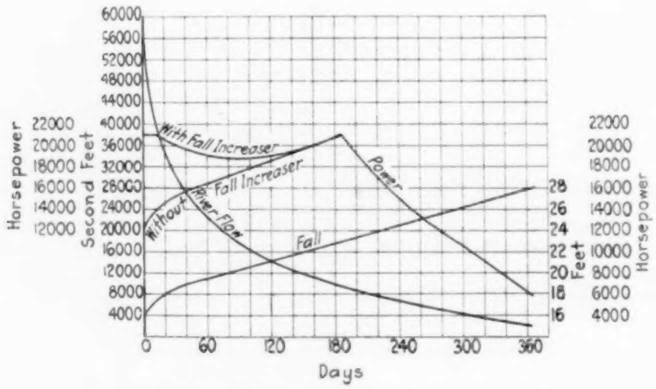

FIG. 3 FALL INCREASERS AT KANAWHA FALLS

lasting in all some 180 of the days of the year; and the estimated construction cost (my estimate) was one million dollars. From this case—a very favorable one—the net advantages conferred range towards nothing, until in other cases, with rivers of a different regime, those advantages wholly disappear.

Dr. Ernst Duebi, at one time of Zürich, Switzerland, repeated the writer's tests, in 1911, at Zürich, and added much information to that previously known concerning the fall increaser. The results were published in book form by Rascher & Cie., of Zürich and Leipzig, 1912.

The essential results found in the writer's tests are shown in Fig. 1.

Fig. 2 shows a design of power house, with fall increasers, made for the City of Geneva, Switzerland; site not yet built upon. That the design had novelty in 1907 may be gathered from the fact that patents were issued for it by the United States, Canada, France, Switzerland, Italy, Sweden and Germany.

At the site named, the water upstream from the power house is lowest (must be *held* lowest), in times of freshet in the river; there being lift gates designed to create the mill pond, instead of a dam. At the same time there is backwater; or in other words, the fall is reduced doubly (shutting up like an accordion); which accounts for the elevation of H. W. shown on the drawing, being at a *lower* elevation than that of L. W.

Note the ready means supplied by fall increasers for getting rid of rack-trash. It needs but to be pushed *down*, into the suction area of the fall increasers, to pass through them and out through the tail-race; instead of being laboriously raked *up* and carried ashore and away.

It is evident that to enable the use of freshet water to operate the fall increasers, a head race of any material length is inadmissible. The power house must be at or very near the dam. This requirement eliminates the majority of hydroelectric plants from a consideration of fitting them with fall increasers.

The next elimination takes place when the character or regime of the river is taken into consideration. Rivers differ in this respect far more than one would suspect; and a careful analysis of their modes of flow during all the days of several years, the more the better, are required, before their regimes may be adequately portrayed. This is done by setting up for them what have been called "duration curves." Every engineer knows what hopeless looking messes a plotted series of daily discharge "curves," (or pictured saw teeth) make, the ordinates representing *consecutive* days of the year the abscissae representing gage heights, or second-feet of river flow. But let each year be represented by these same daily quantities, plotted in the order of their size, and we get at once a smooth curve of quantities flowing in the river for the 365 days of the year, useful in more ways than one. Fig. 3 shows such a curve of river flow. See also, on this point, Transactions Am. Soc. C. E., 1907, a tabular analysis of 20 years' flow of the Connecticut River, at Holyoke, Mass., which could readily be converted into curves such as have been spoken of; and Document 1400, H. R., 62nd Congress, 3d Session, 15 years' flow of the Potomac River at Great Falls near Washington, represented both in tabular and diagram form.

The diagram, Fig. 3, needs little explanation. Besides showing a curve of river flow, it shows the corresponding falls that obtain synchronously at the mill-site under consideration; and from these two the power curve at this mill-site, *without* the use of fall increasers, may readily be computed and plotted. After this we may, with the aid of Fig. 2, compute, and then plot, the power curve for the backwater days of the year *with* the use of the fall increaser; and the area of the diagram included between the last two curves named, gives the total horsepower days or kilowatt-hours, which fall increasers would produce annually forever on that mill-site. Note that at first there is not water enough in the river to operate *all* the fall increasers, causing a sagging down of the curve; which only gradually brings the power curve up and back to normal full power. Here is where the efficiency of fall increasers becomes of great moment.

There only remains to compare their productive value with the interest on the construction cost. The result depends mainly on the regime of the river. Fall increasers are useless where the river flow is effectively regulated by great lakes or reservoirs, causing a uniform discharge of the river. They are uneconomical on rivers that have only a few days of the year of backwater. On the other hand at times a single year's output of kilowatt-hours will nearly pay for their construction cost; and heat engines put in to supplement the low water run of the river, can not afford to burn fuel in competition with the cost of kilowatt-hours when produced by the fall increasers in the days of freshet water during the year.

It would also seem that tide mills, which may have an inexhaustible water supply, but which all have a greatly varying fall during the 24 hours, could materially benefit by the use of fall increasers; and if the "discharge accelerator" will show up the proper cost and efficiencies, it could presumably compete in this and other cases.

R. L. Daugherty.[1] The writer has been much interested in this paper by Mr. Replogle. It is hard for some people to realize that a water power plant may have to shut down because of a superabundance of water as well as because of lack of water. Such a situation is only met with in the case of a low head plant where the fall available may be almost destroyed in time of flood. The writer has found it necessary to explain a number of times why it is that such a fall decreases in time of high water. This point is illustrated in Fig. 4. This photograph, while of a relatively small stream, shows the effect just as well as one of a much larger stream and fall. In this particular case the depth of water flowing over the crest of the submerged dam was practically equal to the height of the dam above the bed of the canal. It may be seen that the dam does little more than create a disturbance in the flow of the water, and the fall is very slight. In fact a portion of this very small fall is due to the fact that some of the water is diverted at this point.

Fig. 4 Low Head in Time of High Water

Under such circumstances the amount of water consumed by a turbine will be much less than the normal amount, and the head being less also the power will be seriously reduced. The device which Mr. Replogle has employed makes it possible to consume more water and thus to compensate for the reduction of head.

It would be of considerable interest if we knew the amount of water actually discharged by the turbines during the tests made by the author, and also the additional water used to produce this effect. It is to be hoped that the author will be able to secure this data at some future time.

It is well known that it costs more per horsepower to develop a given amount of power under a low head than under a high head. As the author states, many low head powers are not utilized, though there is an abundance of water, due to the high cost. Such a device as this, used constantly, converts a low head plant into one of somewhat higher head. The actual amount of water consumed by the plant including that wasted through the accelerators may not be much more than the amount required to develop the same power under the lower head without the accelerators. It would be interesting if the author could give comparative efficiencies in such a case. Of course for the discharge of flood waters only, the efficiency is of no consequence, but for constant use it would be.

While this accelerator is different in detail, it seems to be similar in principle to the fall increaser described by Clemens Herschel in *Engineering News,* Vol. 73, p. 84.

[1] Assist. Professor of Hydraulics, Sibley College, Cornell University.

The Author. In reply to Mr. Dougherty, data regarding the amount of water actually discharged during the tests could not be procured at the time the tests were made. Some data have been secured in preliminary tests of a very small turbine, and these compare favorably with the results secured by Mr. Herschel.

It was preferred to make no reference to efficiency tests until such tests could be made in a logical and comprehensive manner. These will be made in the course of further development.

Of constructions suggested by other engineers the author obtained his first knowledge through the U. S. Patent Office. He believes the construction described is original.

Any construction designed for the purpose of mechanically mixing the two streams of water is erroneous from an efficiency point of view. Mixing implies eddies, and eddy currents transform the kinetic energy in the inducer water into heat. In the preliminary tests the very poorest results out of several hundreds were from a carefully designed mixer.

In reply to Mr. Herschel, there can be no doubt of the real values to be obtained from the use of the atmospheric head with surplus water. The means applied are of no special importance. The doubt in Mr. Herschel's mind is in regard to efficiency, but as he says best overall efficiency is in returns from investment.

The efficiencies quoted by Mr. Herschel seem to be low. From the author's point of view the apparatus he shows has been provided with the best possible means to produce eddy currents and friction. The grating or perforated throat certainly impedes the inducer stream. The turbine water entering at right angles to the inducer stream causes endless eddy currents. The abrupt orifices are causes of much friction. It is possible that if the whole throat section were removed the efficiency would be as high as that stated.

In conclusion, it was thought that the facts gathered to date regarding the accelerator described in the paper might be of interest, but the author has substantial reasons to believe that much higher efficiencies than those given can be obtained from this class of apparatus.

OIL ENGINE VAPORIZER PROPORTIONS, Louis Illmer

DISCUSSION

Wm. T. Price (written). The author has invaded a very difficult field and has carried his calculations as far as reasonable general assumptions will permit.

The subject of vaporizer proportions involves so many factors requiring for practical mathematical treatment so many specific assumptions, that the only safe method to follow is backward calculation and interpolation. Exterpolation, even to a moderate degree, I have found to be not very reliable.

Mr. Illmer assumes for the Hornsby-Akroyd vaporizer a uniform input of heat over the entire inner surface of the cap and a marked temperature gradient from center to edge. This is not correct. With this engine the spray strikes the cap on the side at an angle, and at this point instead of an input of heat there is a momentary subtraction, as heat is given up to gasify the liquid fuel. At full load a dark area is usually plainly evident; around this region the temperature is higher, and then the color dies out to a black at the edge. Mr. Illmer has pointed out that the contact of the cap with the water-cooled portion is only over the area of a narrow copper gas-

ket; the temperature gradient must therefore be explained as being due to radiation and convection from the large flange area.

With the De La Vergne type FH engine, using air injection, the input of heat to the vaporizer does appear to be uniform over the interior surface, but examination of the hot vaporizer shows no perceptible temperature gradient. At full load in a dark room there is usually a dark red color of uniform shade from end to end. The output of heat seems to be uniform over the whole surface, therefore, the flow of heat to the edge being negligible.

There is a great difference in oils and often with Hornsby-Akroyd engines the caps must be changed to suit the different fuels. The writer has known cases where it was necessary to insert a metal coil in the vaporizer to maintain the temperature at light loads. When the temperature of a Hornsby-Akroyd vaporizer shows symptoms of dying, first the water circulation is reduced, then the compression is increased by inserting plates between crank pin box on connecting rod, then a ribbed cap is substituted for the plain cap.

The author's comparison of the high compression engine with the vaporizer engine is in the writer's opinion entirely correct, but he appears to lean toward a 2-cycle vaporizer engine with a compression pressure of about 300 lb. per sq. in. and with air injection.

The addition of the vaporizer to allow of reducing the compression from 500 to 300 lb. per sq. in. is only a half-way measure. The compression must be reduced still lower and then we must go further and eliminate the air compressor. Already there is in fairly wide commercial operation a new oil engine which operates without air injection with compression of 150 lb. and with fuel consumption under favorable conditions very slightly below ½ lb. per bhp-hr., a consumption of 0.55 lb. at three quarters to full load being a conservative guarantee.

Mr. Illmer has pointed out the advantages of timed injection and has explained the difficulty of forming a thorough explosive mixture in the reduced time interval allowed. The logical solution of the problem is *first,* an abundance of oxygen to increase the combustion rapidity, suggesting at once a 4-cycle design. *Second,* an efficient mechanical spray to divide the oil into the smallest possible particles so as to present the greatest oil surface to the oxygen; this suggests a certain shape of spray and a uniform distribution of oil particles throughout the spray volume. *Third,* a combustion chamber conforming as perfectly as construction considerations will allow to the natural shape of the spray. *Fourth,* as completely as possible confine the entire charge of air in the vaporizer at the time of injection. *Fifth,* a vaporizer cap located so as to complete the vaporization of heavy oil particles and ignite the charge.

THE AUTHOR. In deriving the formulae presented a series of alternative assumptions were tried out, but the given equations were found to be in best agreement with the Hornsby-Akroyd vaporizer proportions. The primary aim has been to show that rational vaporizer proportions must rest upon something better than a purely empirical basis.

The exception taken by Mr. Price to the assumption made as to the uniform input of heat over the entire inner cap surface of the vaporizer cap appears to be valid inasmuch as the theoretical temperature gradient would not occur in practice. The discrepancy noted resulted from the simplification resorted to in deriving the formulae. A more refined basis for derivation should make allowance for the fact that this temperature head, t_h, is not uniform over the entire cap surface, but is actually smaller at the center than at the edge of the cap.

In addition the oil spray is usually directed against the hot center portion of the cap, which sets up localized cooling and thus further contributes to a reduction of the temperature drop from that expected on the assumed basis of a uniform distribution of input and output heat.

A more complete analysis, taking into account the varying rate of heat input from center to edge of the cap, would no doubt show a temperature distribution more nearly in accord with Mr. Price's observations, but it is thought that such rather involved basis of calculation would not materially alter the average cap temperature t_c as given. This view is based in part upon Prof. Hopkinson's[1] series of non-cooled piston temperature determinations, which show a temperature gradient for the head-plate to be in fair agreement with the drop indicated in the present paper.

Experimental measurement along the lines of Hopkinson's investigations on pistons would no doubt offer the most satisfactory method of finding the actual temperature gradient in vaporizers. Such data would readily make it possible to fix upon the degree of cooling due to the fuel injection and show its effect in reducing the ratio of maximum to average cap temperature, besides providing a check for the series of other dependent assumptions which had to be made as to existing temperature relations.

In closing, the heat flow from center to edge of the cap is not due primarily to the increased external radiation into the atmosphere from the flange surface, as indicated by Mr. Price, but is rather to be explained by direct metallic conduction of heat from the cap flange into the jacketed portion of the vaporizer. While the contact surface of the copper gasket is small, the conducting power of such restricted contact may nevertheless be relatively quite large under the existing temperature head, the effect being analogous to the cooling action exerted by the seat upon the head portion of a poppet valve.

As indicated by the quantitative figures given in the paper, the external radiation of heat into the atmosphere can at best account for but a relatively small portion of the total heat input into the cap. Hence while the restricted gasket contact does serve to prevent excessive cooling of the cap edge, it still has sufficint capacity to conduct away the major portion of the heat received by the cap wall.

[1] "On Heat-Flow and Temperature-Distribution in the Gas-Engine," Proc. Inst. C. E., Feb. 2, 1909.

CORRESPONDENCE FROM MEMBERS OF THE SOCIETY

Provisions have been made by the Publication Committee for Correspondence Departments in The Journal as follows:

A Department for contributed discussions on papers previously published, or new matter.

A Members' Correspondence Department including suggestions on Society affairs.

Contributions for these departments are earnestly solicited.

ADVANCE PUBLICATION OF PAPERS IN THE JOURNAL

To the Editor:

The Journal should be mainly considered from the standpoint of the members who do not live in New York, and who are, for various reasons, unable to attend the meetings of the Society. It is the "means of communication," if one might use this term, between these members and the Society as a whole. Furthermore, these out-of-town members constitute the majority of the total enrollment in the Society.

When a member does not attend the meetings, he often neglects, in the rush of routine work, to send for the advance copies of the papers to be presented. Even those members who have a direct interest in certain papers, and who might contribute valuable discussion, frequently receive their advance copies too late to allow of more than a hurried perusal of them before the meeting.

As soon as the meetings are over, the regular weekly technical journals publish abstracts of all the more important papers, with discussions of the same, and the outside engineer usually reads those reprints. Later on, when the papers and discussions appear in the Journal, he has no keen interest in the matter and does not read it. Even if the Journal were a weekly publication, it would still have to meet the competition of the commercial trade publications in the same way as at present.

Briefly then the situation is that the earlier publication of papers and abstracts in the regular technical weeklies render later publication in the Journal of less value and small interest.

The best remedy for such minimizing of the value of the Journal to the members would seem to be the return to the earlier plan of publishing all papers in the Journal before the meetings. This would place such engineering information before the membership at first hand, would encourage freer and fuller discussion by allowing the members more time to consider the papers and would serve as a spur to men preparing papers, for those received earliest would probably be published at once. Since it has been decided to retain the Transactions in the old form, there would be no specific objection to having discussions presented in later issues separate from the text, as is done in the publications of other societies.

Objection will be raised that the issues preceding a meeting will be unnecessarily large, for authors do not get papers in on time. This could be remedied by making a rule that only papers published in the Journal could be presented at each meeting. Then members submitting late papers would have to allow these to stand over till the next meeting. This would form an incentive to earlier submission of papers.

A. G. Christie.

Baltimore, Md.

RECORDS OF MOTOR TRUCK PERFORMANCE

To the Editor:

The writer has a particular interest in motor driven vehicles for the carrying of goods and because of the economic importance of this means of transportation, and the direct bearing it has on the greater problems of distribution and marketing, and he believes that other members of our Society might well be interested.

Merchants and manufacturers and others owning motor trucks have begun to show more interest in keeping a daily record of their performance, and for this reason accurate operating figures are now being made available. The following results were recently reported by owners employing motor trucks of the same capacity and manufacture but engaged in different industries:

MONTHLY SUMMARIES. 1½-TON TRUCKS FOR NOVEMBER, 1915.

Location	Butte, Mont.	St. Louis, Mo.	Detroit, Mich.	Baltimore, Md.
Business	Who. Groc.	Paint Mfg.	Lumber.	Packers.
Days in service	24.5	25	26	25
Days out for repairs	0	0.5	0	0
Numbr of trips	123	166	94	32
Number of customers	1,230	392	214	900
Load in pounds	307,500	270,640	82,254 bd. ft	79,600
Mileage traveled	803	829	1,502	907
Gallons of gasoline	140	143	228	163
Pints of cylinder oil	48	40	90	73
Pints of transmission oil	16	7	2	1
Pounds of grease	2	0.75	1.5	2.25

DAILY AVERAGES FROM THE ABOVE SUMMARY.

	Butte.	St. Louis.	Detroit.	Baltimore.
Number of trips per day	5	6.64	3.31	1.28
Customers per day	50.2	15.68	8.23	50.2
Weight per day in pounds	12,500	10,825.6	3,164 bd. ft.	3,184
Weight per trip	2,500	1,630	875 bd. ft.	2,487
Mileage per day	32.77	33.16	57.76	36.28
Miles per gallon of gasoline	5.73	5.79	6.59	5.56
Miles per pint of cylinder oil	16.73	20.72	16.69	12.42

The large variations indicated above suggest that many motor trucks are being managed to better advantage than others, and that the operating efficiency in the latter case might well be improved by studying carefully the conditions surrounding the work and advising the owner accordingly.

This work brings into action another branch of engineering which has been developed to a marked degree in some European countries, and this communication is addressed in the hope that other members of the Society having similar work in hand may find assistance through the columns of this Journal.

R. C. Hargreaves.

Detroit, Mich.

TURBINES VS. ENGINES IN UNITS OF SMALL CAPACITIES

To the Editor:

The data regarding economy of turbine driven pumps given in Mr. Barstow's paper on Turbines vs. Engines in Units of Small Capacities (The Journal, September, 1915), does not represent the highest performances that have, up to the present time, been obtained with a turbine driven centrifugal pumping unit.

The geared turbine pumping unit installed at the Ross Pumping Station, Pittsburgh, was the first pumping machine of this description ever built. Since that time other units have been constructed where better results have been obtained. I refer to the official test made by the City of Cleveland of the 30 million gallon centrifugal pumping unit installed at the Kirtland pumping station. This unit showed a duty of 128,400,000 ft. lb. per million B.t.u. or 152,020,000 ft. lb. per 1000 lb. of steam. The unit in question during test showed a delivery of 30.3 million gallons per day against a total head of

236.3 ft.; the steam supplied was 153.58 lb. per sq. in. gage with 102.6 deg. Fahr. superheat, and the turbine exhausting into a vacuum of 28.25 in. of mercury.

It may be of interest for comparison with other data given in Mr. Barstow's paper to analyze what this duty obtained would mean in operating cost. The unit consisted of a turbine reduction gear and two 24-in. pumps operating in series. It occupied approximately a space 10 ft. by 35 ft. and had a total weight of about 57 tons or about 326 lb. per sq. ft. of foundation. The price of the unit including condenser was $35,750, and the price of the bituminous coal burned at the plant averages $1.64 per ton. Assuming the cost of building a foundation at $20,000, and all boilers of a nominal horsepower equal to the steam requirements at $30 per horsepower, interest rate at 4 per cent, and the probable life of twenty years for the complete plant, the annual cost per water horsepower is $23.11, on the basis of twenty-four hours' operation, three hundred and sixty-five days per year of $25.90 per annual water horsepower on the basis of full load operation, sixteen hours per day.

Mr. Barstow, discussing boiler feed pumps, gives the impression that turbine driven centrifugal boiler feed pumps of less than 250 gallons per minute are not practicable. In this connection I would like to add to Mr. Barstow's data that centrifugal boiler feed pumps are built and used in quite large numbers in quantities ranging from 50 to 200 gal. per min. I would like to cite one instance where a small boiler feed pump of the centrifugal type is used for quite an abnormal condition. The ordinary demand of the boilers requires the pump to deliver an average of 15 gal. per min., due to the condition of the plant load; there may be some days enough demand from the boiler plant to require the feed pump to deliver as much as 60 to 75 gal. per min. The boiler feed pump in this instance is direct driven by a turbine and its speed is controlled by an automatic pump governor, which will change the speed of the unit to suit the requirements of the boiler plant. The pump is handling water at 200 to 210 deg., and is pumping against an average pressure of 200 lb. per sq. in.

C. R. Waller.

Trenton, N. J.

To the Editor:

As Mr. Barstow stated in his paper on Turbines vs. Engines in Units of Small Capacities (The Journal, September, 1915), the general advancement of the steam turbine has been exceedingly rapid. It is not surprising, therefore, that there has been a small region from which the engine has not yet been driven. Small turbines have already begun to invade this field, however. Usually as pointed out by Mr. Barstow, the water rate of a small turbine has been unimportant. By proper selection of the number of stages, number of bucket rows per stage, and wheel diameter for a given horsepower, speed and steam supply, almost any desired water rate can be obtained. Single stage machines with two or three rotating bucket rows have been very popular. Now, however, more efficient turbines are available with a greater number of moving bucket rows. A balance must always be made between increased first cost and increased operating cost.

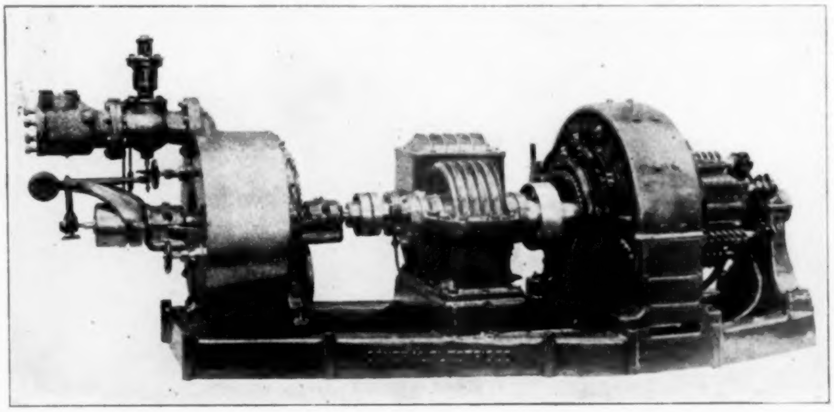

Fig. 1 Example of a Recently Developed Single Stage Turbine

The accompanying photograph (Fig. 1) shows a machine of a type recently developed. These give comparatively good non-condensing water rates, and are designed to meet present-day requirements regarding the balance between simplicity and high efficiency.

One advantage of turbines over reciprocating engines which Mr. Barstow has not mentioned, is the fact that the turbine maintains its original water rate, while many types of engine fall off appreciably. This was very clearly shown in a series of tests published by F. W. Dean in The Journal for June, 1908.

Sanford A. Moss.

Lynn, Mass.

Society Affairs

Engineering Survey

Society Affairs Section..........Page 155
Engineering Survey Section......Page 179

SOCIETY AFFAIRS

ATTENTION is called to the announcement of the Spring Meeting scheduled at New Orleans, La., on April 11-14, and also the announcement of the publication of the report of the Power Test Committee, which will be welcomed by the large number who have anxiously awaited the completion of this testing code. A statement of the important action requested by the President of the United States is given in the report of the special Council meeting, and notices appear in connection with the Engineer Reserve Corps and the new aviation service. The important part taken by the Society in the Pan-American Scientific Congress is also here reported.

SPRING MEETING

PLANS for the Spring Meeting to be held at New Orleans, Louisiana, April 11-14, are nearing completion, and are most promising for a strong meeting and an enjoyable one.

It is probable that there will be a group going or coming by boat and that one or more parties will be formed for the trip by rail. The trip by boat in either direction requires five days, and will be made on one of the best coastwise steamers. Invitations have been received from the local members at Cincinnati and Birmingham for members en route to New Orleans to stop in those cities, and it is possible that arrangements will be made by at least a part of those attending to accept the invitations.

The rate for the round trip from New York is $75, which includes steamship both ways, or railroad going and steamship returning, or vice versa; and includes also meals and berth on steamer. This provides further for those who start from an inland city, such as Cincinnati, to go by rail to New Orleans, and return by steamer to New York and thence by rail to Cincinnati. Round trip by rail between New York and New Orleans is $56.30; Pullman fare, $8.00 for lower berth and $6.40 for upper berth.

The headquarters of the meeting will be at the Hotel Grunewald. The meeting will open as usual on Tuesday afternoon of the week of the Convention, when registration will begin. On Tuesday evening there will be an informal gathering at the hotel.

The first professional session will be on Wednesday morning following the business meeting, at which, besides such technical papers as may be assigned, it is expected that there will be a discussion upon Industrial Preparedness: What It Means, and How It Can Be Accomplished.

Following this meeting the visiting members will be in the hands of their New Orleans friends until Friday morning of the Convention, when the last general professional session will take place. The New Orleans local committee have in preparation one session for their part of the program which will include papers by representative engineers on engineering problems of the South, including papers upon Low-lift Pumping Plants, Multiple Evaporators, such as used in the sugar industry, and a description of the Mechanical Equipment used in the Port of New Orleans.

On Wednesday evening, there will be an address by W. D. Thompson, Commissioner of Public Utilities of the City of New Orleans. Various excursions are being arranged and as the month of April is one of the most delightful of the whole year at New Orleans, the week, under normal conditions, should offer much pleasure to all who attend the meeting.

It is particularly urgent that those who are to contribute papers should send them to the Secretary at the Society headquarters at once, since it is desired to have these papers printed for distribution well in advance of the meeting. It cannot be assured that papers received later than February 10 can be considered for the Spring Meeting and such papers may have to be held over until a later meeting.

Full information as to the program, rates, and routes to be taken will be published in the next number of The Journal, and in a circular which will be issued to the membership.

ANNUAL MEETING

The Committee on Meetings is already considering plans for the next Annual Meeting, and desires to announce that papers which are to be contributed should be in hand by September 20, 1916. On account of the time required for all of the members of the Committee on Meetings to read the papers submitted, and because of the insistence of the membership that the accepted papers be printed and distributed well in advance of the meeting, any papers received after the date mentioned are liable to be held over for a later meeting. In view of the fact that the date announced is immediately following the summer season, which is the usual vacation period, the members are urged to prepare papers during the coming spring so far as possible, and to submit them early in the summer.

REPORT OF POWER TEST COMMITTEE

ON RULES FOR CONDUCTING PREFORMANCE TESTS OF POWER PLANT APPARATUS

The Power Test Committee was appointed by resolution of the Council on April 13, 1909, to "revise the present testing codes of the Society relating to boilers, pumping engines, locomotives, steam engines in general, internal combustion engines, and apparatus and fuels therefor, and to extend these codes so as to apply to such power generating apparatus as the present codes do not cover, including water power, bringing them into harmony with each other and with the best practice of the day."

As originally organized, the Committee consisted of D. S. Jacobus, *Chairman*, Edward T. Adams, George H. Barrus, L. P. Breckenridge, William Kent, Chas. E. Lucke, Edward F. Miller, Arthur West and Albert C. Wood. Dr. Lucke resigned early in 1912 and the vacancy thus made was not filled. Owing to pressure of business duties, Dr. Jacobus resigned the chairmanship in December 1911, but the Committee laid his resignation on the table and appointed Mr. Barrus vice-chairman to serve as active chairman in his place. Later, the Committee accepted the resignation from chairmanship of Dr. Jacobus and promoted Mr. Barrus to the chairmanship, this action being in due time approved by the Council.

The general plan of the revision was devised by Mr. Barrus, who at the Committee's request soon after its appointment, submitted the first draft of a form of report which was afterward substantially agreed upon and carried out. The first

draft was discussed by the Committee, and later the whole matter was referred for revision to a sub-committee consisting of Messrs. Kent, Wood, and Barrus, who were appointed at a meeting of the General Committee in December 1911. The results of the sub-committee's work were approved by a majority of the full Committee and submitted to the Society in a preliminary report which was published in The Journal of November 1912.

This preliminary report was presented at the Annual Meeting in December 1912, and was widely discussed and criticised at the meeting, both verbally and in writing. After that it was further discussed by correspondence. In the light of the suggestions and criticisms attending these discussions, the sub-committee again made an extensive revision, which has now been approved by the entire committee.

The work of the Power Test Committee has been carried on mainly by correspondence, though the sub-committee has held a large number of meetings. Many members of the Society, and a few engineers not members, have commented upon the work, either verbally or in writing, and all comments have received consideration. In a large number of instances, the report has been modified in accordance with the suggestions made by these individuals.

Copies of the proposed report were also sent to the three committees of the Society on Railroads, Gas Power and Bureau of Engineering Standards (now Committee on Engineering Standards), to the Standards Committee of the American Institute of Electrical Engineers, and to the U. S. Bureau of Mines, all of whom were asked for comments. Suggestions received from these sources were availed of in preparing the final revision.

A report of this kind cannot be expected to deal with all the refinements of laboratory tests, or to conform to the methods practiced by every individual who engages in testing work; but it is intended to set forth the correct governing principles and serve the practical purposes of the engineering public.

The final report was received by the Council at its meeting on December 7, 1915, and was ordered printed. This is now in process, and copies will be available at an early date. The report embraces sections on tests of boilers; reciprocating steam engines; steam turbines; pumping machinery; compressors, blowers and fans; complete steam power plants; locomotives; gas producers; gas and oil engines, and waterwheels.

COMMENTS ON ANNUAL REPORT OF COUNCIL

In the January number of The Journal was published the Annual Report of the Council, which reviews the important phases of the work of the Society for 1915, and which it is hoped every member has had an opportunity to look over. In presenting this report at the Annual Meeting, Secretary Calvin W. Rice pointed out features of particular interest to the membership at large. A report of his remarks made at the meeting follows:

In the report of the Council for 1915 there is first shown the progress of the Society with respect to its increase in membership. There are a good many in the Society who have the impression that the present rate of increase of membership cannot be maintained except at the expense of quality. I want to answer this squarely. In this country, which has the largest industrial population of the world, we have, all told, about twenty-five thousand engineers in all of the societies. In Germany, with two-thirds of the population, their one society has more members than all of our societies combined. There are one hundred million people in this country, and more industries and a greater variety of industries than in any other country, and it is reasonable to suppose that our Society, which is the Society of the Industries, should be able to get the leaders of those industries to become members.

The American Society of Civil Engineers has steadily increased its membership, until it now has seven or eight hundred more members than has our Society. The American Institute of Electrical Engineers, specializing on electricity alone, has more members than we have. We have now about sixty-eight hundred members. The object of increasing the membership is not merely to get members, but to acquire greater strength for constructive work so that we may maintain our position with the other national engineering societies.

We have raised the requirements for membership so that now they are the strictest of any professional society in America. Every member of this Society can be assured that no one is being admitted into full membership who is not thirty-two years of age, who has not been ten years in the practice of his profession, and five years in responsible charge of important work. That these conditions exist with respect to each candidate for full membership must be shown in detail and confirmed by five members from their personal knowledge. Each application for membership is viséd by the Secretary, and it is an open secret that no application for membership is ever submitted by him to the Membership Committee if it lacks any of these essentials.

Only after all of these statements in an application for membership have been analyzed and shown to meet the requirements do five members of the Society, the Committee on Membership, sitting as an impartial jury, consider the application. For consideration, five copies of the statements are prepared, so that each one of the five committee members has a file of the replies in front of him. Each member in turn then reads aloud the statements to the others. I cannot see how any man can get by this jury, except as he deliberately misstates the facts and gets five others to say that, from their personal knowledge, all of his misstatements are correct.

Another thing,—formerly it was permissible and considered proper to receive a man into membership who had either the ability to design or to construct. Three years ago we took out the *or* and substituted an *and*, so that now there is no man admitted to this Society who cannot both design *and* construct, and the possibility of a man being admitted to membership who designs things that would never work, or a man who builds things that he could not design, is past. He must have both abilities and be a well-rounded engineer.

It is essential that the financial side of every institution shall be well in hand, and the membership can feel safe on this matter. Since I have been Secretary our income has been increased from $45,000 to $145,000. All of the trust funds are invested in bonds, and we even have a separate fund of $44,772.67 invested to cover the dues of Life and Honorary Members, and as far as I know we are the only Society in the world which does this.

All of the gifts ever made to the Society are intact and invested, and the initiation fees are also invested in a separate fund, amounting now to $43,718.90, which is being used to retire the certificates of indebtedness which were issued for the purpose of paying off our share of the land on which the Engineering Societies Building stands. Our sister societies had some wealthy and generous members, who came forward and

paid off the $180,000 which was each society's share of the purchase price, but we were not so fortunate in this respect, and have had to finance the matter on a different basis. Yet with contributions amounting to only about two-thirds of the gifts received by our sister societies, we were the first to pay off the mortgage on the land by means of certificates issued to the membership. We lack only about $13,000 of being completely out of debt. On the other hand we have enough surplus to pay off that debt at any moment, if desirable to do so, but our funds are invested at the same rate of interest as we are paying on the certificates, so that by reason of the plan we are pursuing, we have the benefit of that extra working capital.

It is the duty and obligation of the officers of any society to act as trustees for the members and to conserve the interests of the members in every proper way. Last year, therefore, when a serious business depression was feared, precautionary measures were taken and we conserved our interests a little more than was proved necessary, but not more than seemed wise, at the beginning of the year. The result is that we saved $26,000 last year to go into the surplus.

Now, the use which can be made of that surplus and of our growing income will be made apparent in the near future. The Council prior to the Annual Meeting voted to strengthen the staff of the Society by the employment of a Business Manager, and we have an ambitious program for the Society for the benefit of every member. Coupled with that is a plan—and emphasis should be put on the fact I now mention—to make every member of this Society take a more active part in its government, and Dr. Jacobus will call later on the Local Sections of the Society to assist him in choosing a Nominating Committee.

The remainder of the features which are embodied in the report can be read by the members at their convenience.

COUNCIL NOTES

At the meeting of the Council held on January 14, 1916, the following members were present: Dr. D. S. Jacobus, *President*, John H. Barr, R. M. Dixon, *Chairman of the Finance Committee*, A. M. Greene, Jr., Henry Hess, Alex. C. Humphreys, F. R. Hutton, C. T. Main, H. de B. Parsons, John A. Stevens, J. E. Sague, William H. Wiley, *Treasurer*, and Calvin W. Rice, *Secretary*.

The following matters were brought up in the order of business and voted upon:

Dr. D. S. Jacobus, Chairman ex-officio, J. H. Barr, Arthur M. Greene, Jr., Henry Hess, Spencer Miller and J. E. Sague were appointed an Executive Committee of the Council for 1916.

Sub-Committee on Gas Power: Heinrich J. Freyn, Chairman, G. F. Gebhardt, Secretary, C. J. Bacon, C. H. Benjamin, A. D. Blake, W. D. Ennis, F. R. Hutton, Wm. T. Magruder, J. M. Spitzglass and H. H. Suplee.

The recommendation of the Committee on Student Branches with regard to the establishment of Student Branches at Bucknell University, Lewisburg, Pa., and Louisiana State University, Baton Rouge, La., were accepted, and F. E. Burpee and E. W. Kerr appointed as the respective Honorary Chairmen.

The President was authorized to appoint a committee of five on the determination of the Cost of Electric Power, to coöperate with the A.I.E.E. and similar committees of other societies, in response to the invitation of the A.I.E.E. through H. G. Stott, representing the Standardization Committee.

Prof. F. R. Hutton, *Chairman*, R. H. Fernald and D. S. Kimball will continue as a Committee on Student Prizes for the year 1916; R. H. Fernald, Chairman, Fred E. Rogers and George B. Brand as a Committee on Junior Prizes. The Boiler Code Committee as constituted for the year 1915 will continue in service for another year. The Committee for the New York Local Section will continue unchanged with the exception of Edward Van Winkle, whose term of office has now expired and who will be succeeded by A. D. Blake, H. R. Cobleigh succeeding as chairman. The activities of the Minnesota Local Section will be cared for by a committee consisting of Chas. W. Tubby, *Chairman*, J. V. Martenis, *Vice-Chairman*, Quincy A. Hall, Wm. Kavanaugh and Max Toltz, in accordance with the nomination of members in St. Paul-Minneapolis.

Announcement was made by the President of the following appointments:

(a) Finance Committee, George M. Forrest
Meetings Committee, D. S. Kimball
Publication Committee, Charles I. Earll (reappointment)
Membership Committee, Fred J. Miller
Library Committee, Walter M. McFarland (reappointment)
House Committee, Maxwell M. Upson
Research Committee, C. C. Thomas
Public Relations Committee, (to be announced later)
Standardization Committee, Henry Hess, John H. Barr, Chas. Day, Carl Schwartz and Wm. F. Kiesel, Jr.
Constitution and By-Laws, Jesse M. Smith, F. R. Hutton, J. E. Sague, Geo. M. Basford, I. N. Hollis
Tellers of Election, Robt. Kirk, *Chairman*, H. A. Hey, E. S. Cooley

(b) Honorary Vice-Presidents, for the meeting of the Society for Promotion of Industrial Education at St. Paul, W. H. Kavanaugh and Max Toltz

(c) Joseph A. Holmes Memorial, Dr. John A. Brashear and W. H. Bixby

(d) Student Branch Chairman (Honorary)
Pennsylvania State College, Hugo Diemer
University of Kansas, A. H. Sluss

(e) Tolerances on Screw Thread Fits, Chas. D. Young, in place of H. M. Leland, resigned.

The Secretary reported that ballots closing November 23 and December 17, 1915, containing the names of applicants recommended to the Council after investigation by the Membership Committee, had been approved by letter ballot, all these newly elected members being duly notified of election to membership in the Society.

The announcements of the deaths of L. M. Brigham, F. S. Scarborough and S. B. Whiting were received with regret.

The vacancy caused by the death of James Mapes Dodge, Past-President of the Society, will be filled by Dr. Alex. C. Humphreys, as announced at the Council Meeting by Major Wiley, Chairman of the Committee on Engineer Reserve Corps. Further information upon this is given elsewhere in this number.

CALVIN W. RICE,
Secretary.

SPECIAL COUNCIL MEETING

TO CONSIDER LETTER FROM PRESIDENT WILSON

A special meeting of the Council was held pursuant to call of the President, Dr. Jacobus, to receive the communication from Hon. Woodrow Wilson, President of the United States, asking for nominations by the Society of a representative in

each state of the Union to act with the representatives of the four other national societies, in making an industrial survey of the country. The letter is as follows:

THE WHITE HOUSE
WASHINGTON

January 13, 1916

MY DEAR SIR:

The work which The American Society of Mechanical Engineers has done through its members on the Naval Consulting Board is a patriotic service which is deeply appreciated. It has been so valuable that I am tempted to ask that you will request your Society to enlarge its usefulness to the Government still further by nominating for the approval of the Secretary of the Navy a representative from its membership for each state of the Union to act in conjunction with representatives from the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Chemical Society, and the American Institute of Mining Engineers, for the purpose of assisting the Naval Consulting Board in the work of collecting data for use in organizing the manufacturing resources of the country for the public service in case of emergency. I am sure that I may count upon your cordial coöperation. With sincere regard,

Cordially yours,

WOODROW WILSON.

Dr. D. S. Jacobus, President, The American Society of Mechanical Engineers, New York City.

There were present at the meeting of the Council, D. S. Jacobus, J. Sellers Bancroft, Alex. C. Humphreys, Julian Kennedy, F. R. Hutton, H. de B. Parsons, Spencer Miller, Ambrose Swasey, William H. Wiley, *Treasurer,* and Calvin W. Rice, *Secretary.*

A tentative list was prepared and a Committee of the President and the Secretary appointed to confer with similar committees of the American Chemical Society, American Institute of Electrical Engineers, American Institute of Mining Engineers, and the American Society of Civil Engineers, which joint committee will prepare the final list that there may be no overlapping in the selection of engineers by the various societies.

THE LIBRARY BOARD

The Library Board administering the libraries of The American Society of Mechanical Engineers, American Institute of Electrical Engineers and American Institute of Mining Engineers, maintained as the Joint Library of the United Engineering Society, according to the By-Laws of that Society, has just issued its annual report for 1915.

LIBRARY OF THE UNITED ENGINEERING SOCIETY

This photograph shows the main floor of the Library. A large part of the books on this floor are bound periodicals which are most frequently consulted. Current numbers of periodical literature are also kept on the main floor. The stack room floor below is mainly devoted to books of reference. The library is made available to all members of the Society through the medium of the Library Service Bureau.

The Board for 1915 consisted of Edward A. Adams, W. P. Cutter, Karl Eilers, Alex. C. Humphreys, F. L. Hutchinson, John W. Lieb, W. M. McFarland, Harold Pender, Calvin W. Rice, E. F. Roeber, Samuel Sheldon, W. I. Slichter, Jesse M. Smith, E. Gibbon Spilsbury, Bradley Stoughton and Leonard Waldo.

A feature of the year's work was the organizing on a definite basis of the service given to members by furnishing reference lists, making translations, and preparing photostat copies. A Library Service Bureau was established on May 6, 1915, and members of the Society were notified of the service proposed.

In July, 1915, the Library published a catalogue of technical periodicals to be found in seven libraries in New York City and vicinity. The total number of periodicals is 2066 and the number of sets 4236.

Over three thousand accessions were made to the Library during the year, and the collection now amounts to 62,446 volumes. Several notable gifts were received during the year from private sources, and a large collection of trade catalogues was donated by the New York Public Library. Dr. James Douglas contributed $5000 to serve as a nucleus for an endowment fund, the income from which should be used for library purposes.

1020 periodicals are now received regularly by the Library, constituting it the greatest and potentially the most useful engineering library in the world. Current numbers of over 1000 periodicals are filed upon the shelves in the reading room so as to be readily accessible.

The Board emphasizes the need of an adequate general index to technical literature. Of the two general indexes now existing, the largest covers only one fifth of the periodicals received. The possession of an adequate index would make it possible for the technical worker, located at any place where he is separated entirely from library facilities, to find articles desired without laborious search and to obtain direct from a central library typewritten or photographic copies and translations. An estimate of the cost of preparing such an index is included in the report.

PAN-AMERICAN SCIENTIFIC CONGRESS

During the month of January the Second Pan-American Scientific Congress concluded its sessions, and accomplished a comprehensive effort to develop our cultural relations with Central and South America. The Congress was held in Washington under the auspices of the Department of State, and convened on December 27, 1915; and no affair ever attracted a more enthusiastic coöperation between the Government and scientific and engineering bodies, and the beneficial results were in proportion and far-reaching.

According to precedent set at the first Congress held at Santiago, Chili, in December 1908, and to the proper interpretation of the Spanish counterpart *scientifice* of our word *scientific*, the second Congress covered all branches of knowledge. Its main activities were divided into nine sections, as follows:

I Anthropology
II Astronomy, Meteorology and Seismology
III Conservation of Natural Resources, Agriculture, Irrigation and Forestry
IV Education
V Engineering
VI International Law, Public Law and Jurisprudence
VII Mining and Metallurgy, Economic Geology and Applied Chemistry
VIII Public Health and Medical Science
IX Transportation, Commerce, Finance and Taxation.

These sections were further divided into subsections as found necessary.

By invitation of the Department of State, the section on Engineering was conducted under the auspices of the five national engineering societies, American Society of Civil Engineers, American Institute of Mining Engineers, American Institute of Electrical Engineers, Society of Naval Architects and Marine Engineers, and The American Society of Mechanical Engineers.

The members representing the Society on the Joint Committee conducting the Engineering Section were Brig. General W. H. Bixby, U. S. A., retired; Prof. Carl C. Thomas; Charles T. Plunkett, and Calvin W. Rice. By choice of all the societies, Brig. General Bixby was appointed chairman of the Joint Committee, and in turn was made a member of the Executive Committee of the entire Congress. Dr. Elmer L. Corthell, President of the American Society of Civil Engineers, was chosen Secretary of the Joint Committee.

Our recently-retired president, Dr. John A. Brashear, was selected by the Department of State as the representative of the United States to the Congress, and the delegates of the Society were Ambrose Swasey, Past Pres. Am.Soc.M.E., and Waldo H. Marshall. Prof. Carl C. Thomas was presiding officer of Subsection 5: Mechanical Engineering.

Among the papers presented at the sessions of the Engineering Section was one by William Kent, Mem.Am.Soc.M.E., on Economy of Steam Power Plants Using Gas, Gasoline, Coal and Other Pan-American Fuels. The calorific values of all fuels obtainable in Pan-American countries, including the lighter oils, tar and some agricultural products, were given, and the paper discussed the conditions governing the choice of each fuel and the costs of operation with the various fuels.

Other papers at the Congress of mechanical engineering interest were those on Present Status of Water Power Development, by H. W. Buck; Hydro-Electric Utilization at Niagara and Elsewhere, by Maurice Deutch; Engineering Nomenclature, by Alberto Smith; Engineering Education in the United States, by Dr. Charles S. Howe, Mem.Am.Soc.M.E., and Chronocyclograph Devices for Measuring Achievement, by Frank B. Gilbreth, Mem.Am.Soc.M.E. During the week of the Congress, Dr. Brashear delivered a particularly instructive lecture on An Evening Journey Among the Stars.

During the Congress, the Secretary of the Society extended to the whole of the delegates an invitation to visit our headquarters and avail themselves of our facilities, and already several of the delegates have called and, among other things, visits to industrial plants have been arranged for them.

At the close of the Congress, the United States Government arranged a tour for the delegates to Philadelphia, New York, New Haven and Boston.

ENGINEER RESERVE CORPS

To the Special Committees of
American Society of Civil Engineers,
American Institute of Mining Engineers,
American Institute of Electrical Engineers,
American Institute of Consulting Engineers,
The American Society of Mechanical Engineers,
on the Organization of a National Engineer Reserve.

Dear Sirs:

The Joint Committee (consisting of the chairmen of your several committees) formed under the authority of the five societies, in order to facilitate the carrying out of the organization of an engineer reserve as part of the military forces of the United States, for which work you were appointed, now beg leave to report as follows:

The Committee has been in personal communication with the Secretary of War, the officers of the General Staff, the officers of the War College, and with the Hon. Geo. E. Chamberlain, Chairman of the Senate Committee on Military Affairs, and the Hon. James Hay, Chairman of the House Committee on Military Affairs.

As the result of these interviews there has been incorporated in the draft of the legislation proposed by the Secretary of War and included also in the bills drawn by the committees of the Senate and of the House, a provision for the organization of an officers' reserve on broad lines, including an engineer reserve. As now drawn these bills provide that an officer shall

be commissioned for a period of five years with rank up to and including that of major, after passing such requirements of character and qualifications as shall be prescribed by the President. The bill also provides that a certain amount of duty with pay shall be performed each year by the officers in the reserve.

The Committee is waiting for the Navy Department to formulate its plans for the increase in the naval forces, and as soon as a decision has been reached by that Department and the Committee is in possession of the facts, the Committee will take up the question of the organization of an engineer reserve for the Navy, similar to that contemplated for the Army.

It is the intention of the Committee to attend any Congressional hearings that may be had on the bill or bills introduced for the creation of an engineer reserve.

Prior to the enactment of the necessary legislation, no enrollment for the proposed reserve can be made.

Very truly yours,

(Signed) Wm. H. Wiley, H. A. Gillis,
John A. Hill, W. F. M. Goss.

THE BOILER CODE IN TECHNICAL SCHOOLS

That the work of the Boiler Code Committee is meeting with increasing recognition is indicated by its use in technical schools as a text or reference book. The A.S.M.E. Boiler Code is being used as a reference book at Stevens Institute of Technology at Hoboken, N. J., at Sheffield Scientific School of Yale University, and in the course in boiler design at the Rennselaer Polytechnic Institute at Troy, N. Y. At Rensselaer, the Code supplements the text and lecture notes; in the actual design work the requirements of the Code are examined and the design made to meet the requirements. It is reported that the Code is also in use at Virginia Polytechnic Institute, Georgia School of Technology, University of Texas, and The Tulane University of Louisiana.

MEMBERS FOR AVIATION SERVICE

Mr. Raynal C. Bolling, Commander Signal Corps, National Guard, State of New York, in a letter addressed to the Society, states that he is especially desirous of securing men whose professional training or business occupations give them particular qualifications for service in the Aviation Detachment of the National Guard. He believes that among the members of the Am.Soc.M.E. there will be many younger men who would make very desirable members of this organization, and asks that those who would like to join the Aviation Detachment communicate with him (c/o U. S. Steel Corp., 71 Broadway, New York).

NOTES

A cordial invitation has been received from F. E. Pierce, secretary of the New York Section of the American Institute of Mining Engineers, for the members of the Society to attend the monthly meetings of the Institute. These meetings are scheduled for the evening of the first Wednesday after the first Tuesday of each month, from October to May inclusive. The notices are sent out to the members and associates ten days or two weeks in advance of the date set, and duplicate notices may be obtained in the rooms of the A.I.M.E. It is the present custom to hold these meetings at the Machinery Club, 50 Church St., preceded by a dinner at 6.30 p.m., the cost of which is $1.50 per plate.

APPLICATIONS FOR MEMBERSHIP

TO BE VOTED ON MARCH 10, 1916

Members are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their ages qualify them and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate Member, those in the next class under Associate-Member or Junior, and those in the third class under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. The Candidates will be balloted upon by the Council unless objection is received by March 10, 1916.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Adams, Clarence S., Draftsman and Designer, Engrg. Dept., Copper Queen Cons. Mining Co., Douglas, Ariz.
Allen, J. S., Ch. Engr. and Supt., Metropolitan Dredging Co., New York
Andersen, Oscar E., Mgr. Chicago Off., Wheeler Condenser & Engrg. Co., Chicago, Ill.
Austin, Harold R., Ch. Engr., Chimney Dept., The M. W. Kellogg Co., New York
Banch, Ladislaus R., Designing Engr., Corrigan, McKinney & Co., Cleveland, Ohio
Billings, David L., Asst. Secy. and Systematizer, Remington Arms Co. of Delaware, Eddystone, Pa.
Bower, Clarence B., Efficiency Engr., Carnegie Steel Co., New Castle Wks., New Castle, Pa.
Cavin, Gustave, Asst. Mech. Engr., Canadian Locomotive Co., Ltd., Kingston, Ont., Canada
Charlton, Richard C., Mech. Engr., Henry Disston & Sons, Philadelphia, Pa.
Corey, Varian S., Supt., The Hampden Watch Co., Canton, O.
Donovan, William P., Supt., Gypsy Oil Co., Kiefer, Okla.
Francois, Richard G., Cons. Engr., New York
Hoffmann, Karl F., Cons. Mining Engr., New York
Holcombe, Amasa M., Patent Lawyer, with Carr & Carr, Attys.-at-Law, St. Louis, Mo.
Johnson, Francis E., Jr., Ch. Engr. and V. P., The M. W. Kellogg Co., New York
Kingsbury, W. P., Constr. Engr., Gypsy Oil Co., Tulsa, Okla.
May, Edwin M., with The Richardson-Phenix Co., Milwaukee, Wis.
Messer, Vladimir V., Engr., with P. R. Moses and Frederick Pope, Cons. Engrs., New York
Mooney, James D., with Hyatt Roller Bearing Co., Newark, N. J.

Mowery, Harold W.,
American Abrasive Metals Co., New York
Oederlin, Frederick, Mem. Genl. Management,
Messrs. Sulzer Bros., Winterthur, Switzerland
Rhines, George, Genl. Supt.,
Stanley G. Flag & Co., Stowe, Pa.
Roane, R. Royal, Mech. Engr.,
James Stewart & Co. Inc., and Canadian Stewart Co., Ltd., New York
Rogers, A. A., Pres.,
Portales Utilities Co., and Portales Pwr. & Irrigation Co., Portales, New Mex.
Romann, John H., Maintenance Engr.,
Amer. Steel Foundries, E. St. Louis, Ill.
Sandstrom, Charles C., Mech. Engr.,
Hunt Engrg. Co., Kansas City, Mo.
Sladky, Alexander C., Asst. Supt.,
Natl. Enameling & Stamping Co., Milwaukee, Wis.
Starkey, Lewis C., Prof. of Mech Engrg.,
Drexel Inst., Philadelphia, Pa.
Steere, Robert E., Master Mech. and Ch. Engr.,
Nashawena Mills., New Bedford, Mass.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Bertram, H. Graham, Mech. Engr. Order Dept.,
John Bertram & Sons, Dundas, Ont., Canada
de Bruyn, Charles E., Mgr. of Efficiency Instr. Dept.,
Scientific Materials Co., Pittsburgh, Pa.
Elmes, Clyde C., Asst. Supt. M. P. and Rolling Equipment,
Philadelphia & Reading R.R., Reading, Pa.
Farrar, John G., Asst. Ch. Draftsman,
McIntosh & Seymour Co., Auburn, N. Y.
Flood, Henry, Jr., Ch. Engr.,
Central Hudson Gas & Elec. Co., Poughkeepsie, N. Y.
Lynch, Albert S., Efficiency Engr.,
Winchester Repeating Arms Co., New Haven, Conn.
Mervine, Arthur E., Ch. of Service and Maintenance Dept.,
New Jersey Zinc Co., of Pa., Palmerton, Pa.
Palmer, Guernsey A., Draftsman,
J. P. Devine Co., Buffalo, N. Y.
Sheedy, Michael M., Ch. Insptr.,
Penn. Mfrs. Assoc. Casualty Ins. Co., Philadelphia, Pa.
Smith, Edward W. G., Chief Draftsman,
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Thomas, Stephen, Special Apprentice,
Hooven Owens Rentschler Co., Hamilton, Ohio
Thompson, Uldric, Jr., Engr.,
Internatl. Steel & Ordnance Corp., Parlin, N. J.
Volkmar, Walter H., Investigation and Time Study,
Winchester Repeating Arms Co., New Haven, Conn.

FOR CONSIDERATION AS JUNIOR

Betts, Walter L., Asst. to Genl. Foreman, Bayonet Dept.,
Remington Arms & Ammunition Co., Bridgeport, Conn.
Blakeman, Samuel P., Mech. Draftsman & Designer,
The Terry Steam Turbine Co., Hartford, Conn.
Bready, William M., Jr.,
with The Kennicott Co., Chicago, Ill.
Carpenter, Frederick S., Engrg. Dept.,
United States Rubber Co., New York
Day, Oscar L., Asst. Designer,
Harbison-Walker Refractories Co., Pittsburgh, Pa.
Fenton Paul, Engr.
Amer. By-Product Mchy. Co., New York
Harris, Murray W., Asst. to Dept. Supt., Gun Shop,
Remington Arms & Ammunition Co., Bridgeport, Conn.
Hoffman, Armin S., Mech. Engr.,
with B. P. Clapp Ammonia Co., Washington, D. C.
Kneass, Strickland, Jr., Asst. Steam Engr.,
Youngstown Sheet & Tube Co., Youngstown, O.
Koch, William H., Jr., Asst. Supt.,
A. & F. Brown Co., Elizabethport, N. J.
Mankin, Clarence E., Dist. Supvr. of Service,
Studebaker Corp. of America, New York
Patterson, James C., Mech. Engr.,
The Standard Cotton Co. of Amer., Philadelphia, Pa.
Shaffner, Charles R., Steam Expert,
Illinois Steel Co., Joliet, Ill.
Smith, Charles W., Efficiency Engr.,
Inspiration Cons. Copper Co., Miami, Ariz.
Snavely, Amos B., Genl. Engrg. Wk.,
Hershey Chocolate Co., Hershey, Pa.
Walter, Edford M.,
with B. F. Sturtevant Co., Boston, Mass.
Wellons, Charles M.,
with The Curtiss Aeroplane Co., Buffalo, N. Y.
White, William C., Designer,
The Moulton Engineering Corp., Portland, Me.
Wilkins, Charles N., Asst. to Mgr.,
Air Conditioning Dept., Warren Webster Co., Camden, N. J.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM JUNIOR

Crawford, Charles C., Mgr.,
A. M. Lockett & Co., Ltd., Houston, Tex.
Elliott, Benjamin G., Assoc. Prof. of Mech. Engrg.,
Univ. of Nebr., Lincoln, Nebr.
Rowse, William C., Prof. of Mech. Engrg.,
Univ. of Manitoba, Winnipeg, Man., Canada
Singer, Sidney C., Supt. of Distribution,
Syracuse Lighting Co., Syracuse, N. Y.

PROMOTION FROM ASSOCIATE-MEMBER

Lang, Charles W., Ch. Ord. Engr.,
U. S. Standard Arms Co., Inc., New York

SUMMARY

New applications	61
Applications for change of grading:	
Promotion from Junior	4
Promotion from Associate-Member	1
Total	66

GEOGRAPHICAL INDEX

Arizona
Douglas—Adams, Clarence S.
Miami—Smith, Charles W.
Connecticut
Bridgeport—Betts, Walter L.
Harris, Murray W.
Hartford—Blakeman, Samuel P.
New Haven—Lynch, Albert S.
Volkmar, Walter H.
District of Columbia
Washington—Hoffman, Armin S.
Illinois
Chicago—Andersen, Oscar E.
Bready, William M., Jr.
E. St. Louis—Romann, John H.
Joliet—Shaffner, Charles R.
Maine
Portland—White, William C.
Massachusetts
Boston—Smith, Edward W. G.
Walter, Edford M.
New Bedford—Steere, Robert E.
Missouri
Kansas City—Sandstrom, Charles C.
St. Louis—Holcombe, Amasa M.
Nebraska
Lincoln—Elliott, Benj. G. (J.)
New Jersey
Camden—Wilkins, Charles M.
Elizabethport—Koch, William H., Jr.
Newark—Mooney, James D.
Parlin—Thompson, Uldric, Jr.
New Mexico
Portales—Rogers, A. A.
New York
Auburn—Farrar, John G.
Buffalo—Palmer, Guernsey A.
Wellons, Charles M.
New York—Allen, J. S.
Austin, Harold R.
Carpenter, Frederick S.
Fenton, Paul
Francois, Richard G.
Hoffmann, Karl F.
Johnson, Francis E., Jr.
Lang, Charles W. (A.M.)
Mankin, Clarence E.
Messer, Vladimir V.
Mowery, Harold W.
Roane, R. Royal
Poughkeepsie—Flood, Henry, Jr.
Syracuse—Singer, Sidney C. (J.)
Wellons, Charles M.
Ohio
Canton—Corey, Varian S.
Cleveland—Banch, Ladislaus R.
Hamilton—Thomas, Stephen
Youngstown—Kneass, Strickland, Jr.
Oklahoma
Kiefer—Donovan, William P.
Tulsa—Kingsbury, W. P.
Pennsylvania
Hershey—Snavely, Amos B.
Eddystone—Billings, David L.
New Castle—Bower, Clarence B.
Palmerton—Mervine, Arthur E.
Philadelphia—Charlton, Richard C.
Patterson, James C.
Sheedy, Michael M.
Starkey, Lewis C
Pittsburgh—Day, Oscar L.
de Bruyn, Charles E.
Reading—Elmes, Clyde C.
Stowe—Rhines, George
Texas
Houston—Crawford, Charles C. (J.)
Wisconsin
Milwaukee—May, Edwin M.
Milwaukee—Sladky, Alexander C.
Canada
Dundas—Bertram, H. Graham
Kingston—Cavin, Gustave
Winnipeg—Rowse, William C. (J.)
Switzerland
Winterthur—Oederlin, Frederick

PERSONALS

THIS department is intended for items about members of the Society, their professional work and incidents concerning them which may be of interest to the membership in general. Items are solicited upon important engineering developments in which members have been associated, and also newspaper clippings or manuscripts of addresses delivered by members at meetings of any kind are desired. It is hoped that every member of the Society will furnish an interesting item occasionally for publication in the Journal.

George A. Wieber has accepted the position of chemist with The Bartlett Haywood Company of New York. He was formerly employed by the Westinghouse Machine Company, East Pittsburgh, Pa., as an engineering apprentice.

John E. Taylor, until recently associated with the New York Central and Hudson River Railroad Company at Canastota, N. Y., has become identified with the Locomotive Superheater Company, New York, in the capacity of draftsman.

Frank C. Clark, superintendent of the Pacific Locks, Panama Canal, at Pedro Miguel, Canal Zone, has accepted a position with the New Castle Construction Company, New Castle, Del., as superintendent.

Le Roy Hilyard has entered the employ of Edward G. Budd Manufacturing Company, Philadelphia, Pa., as assistant engineer. He was until recently affiliated with the International Steam Pump Company of Philadelphia, Pa.

Ernest O. Hickstein is no longer connected with the Wichita Natural Gas Company, Bartlesville, Okla., having accepted a position in the stoker department of the Westinghouse Machine Company, East Pittsburgh, Pa.

William A. Cowell, formerly designer and checker with the McIntosh and Seymour Corporation of Auburn, N. Y., has accepted the position of chief draftsman with the William Tod Company of Youngstown, O.

James W. Smith has recently severed his connection as works manager of the Wyman and Gordon Company, drop forgers. Mr. Smith was formerly connected with the American Steel and Wire Company at Pittsburgh, Pa.

William J. A. London has accepted a position with the Sterling Blower Company, Hartford, Conn., in the capacity of works manager. He was until recently chief engineer of the Terry Steam Turbine Company of the same city.

Otto S. Beyer, Jr., formerly general foreman of the Rock Island Lines at Horton, Kan., has become associated with the University of Illinois, Urbana, Ill., in the railway engineering department.

Arthur F. Murray has become affiliated with the New England Westinghouse Company, Springfield, Mass. He was until recently equipment engineer of the Blake and Knowles Steam Pump Works at East Cambridge, Mass.

Waldemar R. Kremer was appointed general sales manager of the Vilter Manufacturing Company, Milwaukee, Wis., at the recent meeting of the board of directors, succeeding the late Fred Ulrich. Mr. Kremer has been connected with the company for nearly ten years as consulting electrical and mechanical engineer in the sales department. In his new capacity he will have general charge of sales and supervision of branch offices and agencies in this and foreign countries.

Walter N. Polakov has opened an office in New York, for the practice of consulting engineering.

Paul M. Lincoln, whose connection with the Westinghouse companies in their operating and engineering activities dates back for over 23 years, has become associated with the sales organization of the Westinghouse Electric and Manufacturing Company with the title of commercial engineer.

Ervin G. Bailey, who has been associated with the Fuel Testing Company, Boston, Mass., for the past six years, has been made president of the Bailey Meter Company of Boston, Mass., which has perfected a line of recording and integrating meters for measuring the flow of steam, water, air and other fluids.

Russell Huff, chief engineer of Dodge Brothers, Detroit, Mich., was elected president of the Society of Automobile Engineers at its annual midwinter meeting in New York, January 5.

In the January 20 issue of the American Machinist is published the first of a series of articles by Charles Piez, on the Personal Reminiscences of James Mapes Dodge. This article deals with the development of the conveying and coal storage business and covers a period of Mr. Dodge's life to about 1900.

G. W. Lewis and A. G. Cressler are co-authors of an article on Empirical Design of Gas-Engine Piston Pins which appears in the January 20 issue of American Machinist.

Elmer A. Sperry is one of the winners of the medals awarded by the American Museum of Safety for meritorious work in promoting safety and conserving life. Mr. Sperry will receive the Scientific American medal for his gyroscopic compass.

H. M. Byllesby has been appointed a member of the public service corporation committee of the Investment Bankers' Association of America.

Charles A. Stone, president of the American International Corporation, New York, and a member of the firm of Stone and Webster Engineering Corporation of Boston, Mass., has been elected president of the alumni council of the Massachusetts Institute of Technology.

Bernard Lester has been appointed manager of the small-motor section of the industrial department of the Westinghouse Electric and Manufacturing Company.

Thomas A. Edison, Hon.Mem.Am.Soc.M.E., was the guest of honor at the thirtieth annual banquet of the Ohio Society of New York at the Waldorf-Astoria Hotel, January 15. Preparedness for Defense was the subject of addresses by Hon. Henry D. Estabrook, the Reverend S. Parkes Cadman, D.D., and the Hon. Josephus Daniels, Secretary of the Navy.

John L. Harper, chief engineer for the Hydraulic Power Company, Inc., of Niagara Falls, N. Y., has been appointed supervising engineer of the Niagara Falls Grade Crossings Commission.

F. H. Newell, of the department of civil engineering, University of Illinois, will be the speaker at the annual dinner of the Minnesota Surveyors' and Engineers' Society on February 11.

Frederick W. Ballard, formerly commissioner and chief engineer of the light and heat division of the City of Cleveland, is now connected with the firm of F. W. Ballard and Company, engineers, Cleveland, O.

S. P. Brown, chief engineer of the Mount Royal Tunnel and Terminal Company, Ltd., Montreal, Canada, has contributed to the Engineering Record a series of articles on Tunnel Drill Carriages—Their Economic Possibilities. The first and second articles, which appear in the January 8 and January 15 issues, discuss the evolution of the drill carriage and the adaptation of European and American ideas to an advanced type of heading carriage used in the Mount Royal Tunnel. The third and last article, which is published in the January 22 issue, deals with the work done by unique types of drill carriage for bench work and trimming.

George W. Bissell, dean of engineering of Michigan Agricultural College, East Lansing, Mich., was elected president of the Michigan Engineering Society at the January 18-20 convention in Grand Rapids.

W. B. Goentner, formerly assistant engineer of the Department of Water Supply, Gas and Electricity of New York City, has been appointed superintendent of the factory of the McCabe Chemical Company at Charlotte, N. C.

John A. Mathews, president of the Halcomb Steel Company, Syracuse, N. Y., addressed the Chicago section of the American Institute of Mining Engineers, January 14, on Iron in Antiquity and To-Day.

L. A. Perkins, mechanical engineer at the Addyston, O., works of the United States Cast Iron Pipe and Foundry Company, has been made assistant superintendent of the company's plant at Bessemer, Ala.

Werner Nygren has withdrawn from the firm of Nygren, Tenney and Ohmes, New York, and has established independent offices for the practice of consulting engineering in steam power, heating and ventilating installations at 101 Park Avenue, New York.

Arthur L. Jennings has retired as president and general manager of the Russell-Jennings Manufacturing Company of Chester, Conn.

William R. Blair, formerly works manager of the Landis Machine Company, St. Louis, Mo., has accepted a similar position with the Measuregraph Company of St. Louis, Mo., makers of a yardage measuring instrument for stores and warehouses.

Walter B. Snow and staff, advertising agents and publicity engineers of Boston, Mass., have added to their organization, Charles W. Burrage, formerly instructor in mechanical engineering at the Massachusetts Institute of Technology and associated with the F. W. Dodge Company in connection with the preparation of Sweet's Index.

E. Gybbon Spilsbury was elected president of the Engineers' Club of New York on January 25.

Jos. C. Regan has accepted a position with the Timken-Detroit Axle Company of Detroit, Mich., as general factory manager. He was until recently assistant general superintendent of the Yale and Towne Manufacturing Company, Stamford, Conn.

Milton R. Jonas has become associated with the Allegheny By-Products Company of Glassport, Pa.

Arthur C. Merrill, until recently connected with the Bureau of Water, Department of Public Works of Philadelphia, Pa., in the capacity of district engineer, has accepted a position with the E. I. du Pont de Nemours and Company at Carneys Point, N. J., as assistant supervisor of production.

George B. Kaley, formerly employed by the Taylor-Wharton Iron and Steel Company, High Bridge, N. J., as chief draftsman, has become affiliated with the Ross Rifle Company of Quebec, Canada.

George W. Scott has become connected with the H. H. Franklin Manufacturing Company, Syracuse, N. Y., as plant engineer. He was, until recently, identified with the Faultless Rubber Company of Ashland, O., having had charge of the mechanical department.

NECROLOGY

FRANCIS WINTHROP SCARBOROUGH

Francis Winthrop Scarborough was born in Cincinnati, Ohio, on September 6, 1865. He received his preparatory education in the public schools of Cincinnati and graduated from the Rensselaer Polytechnic Institute in 1888. Soon after this, he entered the service of the Chesapeake and Ohio Railway Company as engineer, from which service he resigned in 1908. While with the railway he became Engineer of Bridges and Signals and at the time he resigned was Chief Engineer of Maintenance of Way and Structures. Immediately after his resignation he became actively engaged in the operation of coal mines in the New River region of the Chesapeake and Ohio Railway Company. Here he held the position of General Superintendent in charge of the operation and development of eight coal companies controlling 30,000 acres of coal land and shipping at that time over one million tons annually.

He was a member of the American Society of Civil Engineers, American Institute of Mining Engineers, American Society for Testing Materials, and American Railway Association. He became a member of the Society in 1905.

Mr. Scarborough died in New York City on December 24, 1915.

RAFAEL ESTRADA

Rafael Estrada was born in Havana, Cuba, on October 19, 1840. He received his early education in Cuba and later went to Lowell, Mass., where he was instructed privately. During 1855 and 1856 he served an apprenticeship in the machine shop of William Sellers & Company, of Philadelphia, and then resumed his studies in Cuba. In 1860 he entered the Southwark Foundry & Machine Company as an apprentice and rapidly rose to the position of erecting engineer, having charge of the erection and starting of sugar mills on several of the large plantations in Cuba and the Facala Refinery in Peru, S. A. In 1870 he became manager of the Grocers Sugar House in Philadelphia, and remained there until the house was closed in 1891. In 1892 he took charge of the sugar business of Bea Bellido & Company in Cuba, for whom he designed, completed and managed a molasses sugar house. From 1897 to 1904 he owned and operated zinc and lead mines in Joplin, Mo., but in 1904 he resumed his activities in the Cuban sugar industry, During this time he was active in the reconstruction and management of sugar mills on several large plantations and was retained as consulting engineer on several others.

Mr. Estrada became a member of this Society in 1904. He died at his home in Cuba on December 26, 1915.

WILLIAM H. DOANE

Dr. William H. Doane was born near Norwich, Conn., on February 3, 1832. He received his early education at Woodstock Academy in Connecticut, and later went to Cincinnati, where he took an active part in business and religious affairs. He was president of the J. A. Fay & Co., wood machinery makers, for many years, and when the firm was consolidated with the Egan Company he relinquished his connection with the enterprise. At the Paris Exposition in 1889, Dr. Doane was one of the three Americans to receive an award of honor. His exhibit of woodworking machinery was one of the features of the display in the French capital.

Dr. Doane's chief interest was music. He was granted the degree of Doctor of Music and wrote many compositions. His great interest in harmony caused him to take an extensive trip to many lands and in his world journey he collected marvelous groups of instruments. The collection aroused considerable interest among music lovers and Dr. Doane presented it to the Cincinnati Art Museum, where it is preserved.

He was elected to membership in the Society in 1885. He was President Emeritus of the American Baptist Publishing Company of Philadelphia, Trustee of Denison University, Granville, Ohio, and was affiliated with a number of religious societies.

He died at the home of his daughter in South Orange, N. J., on December 23, 1915.

LOCAL MEETINGS

It is of the highest importance in the development of the monthly meetings of the Society, both of the Local Sections and of the Student Branches, that comprehensive reports of these meetings be published in The Journal regularly. Secretaries of the sections and student branches are urged to make every effort to get the complete reports of their meetings to this office as quickly as possible after the meetings are held, and also where possible, copies of the papers presented should be sent in; if desired, the copy of the paper will be returned after examination. The reports of meetings in order to appear in the next issue of The Journal must be received in this office before the 18th of the month.

LOCAL SECTIONS

ATLANTA, NOVEMBER 22

On November 22, 1915, the Affiliated Technical Societies of Atlanta held a meeting at which Mr. Speller of the National Tube Works of McKeesport, Pa., gave a lecture on Steel Making from the Ore to the Finished Product. His lecture was illustrated with moving picture films showing the manufacture of the steel company's product.

J. E. Latta of the Underwriter's Laboratory of Chicago, Ill., presented moving picture illustrations of the testing work of the laboratory and gave a discussion of the pictures as they were shown.

MILWAUKEE, DECEMBER 15

At a meeting of the Milwaukee Section, held on December 15, W. B. Hanlon, Consulting Engineer, President of the Cleveland Engineering Society, gave an address of The Relationship That Should Exist Between the Engineers' Society and the Administration of Municipal Affairs. To illustrate his subject, Mr. Hanlon took as an example the Cleveland Engineering Society and cited some instances of its activities in matters of public policy.

At the late November election, three important ordinances relating respectively to the proposed New Union Station, which involved the exchange of city property with one of the railroad companies; four track freight subway extending across the city under East 55th Street, embracing a harbor terminal on the Lake front, and the Cleveland and Youngstown rapid transit terminal, which embraced the closing up of several streets and the establishment of a large freight terminal on the level with the city's principal warehouse and wholesale district, were submitted to a referendum vote of the membership of the society. About two weeks before the election a meeting was held at which each one of the projects was presented by the respective engineers and discussed, and afterwards a general discussion took place, with the result that on election day each ordinance was approved.

Another case was that in which a society in southern California requested the Cleveland Society to join it in recommending to the Government a change in the weather observation stations in that State. As the result of a request to the Government for information, an observer at the Cleveland Weather Station and another from the Washington Office of the U. S. Geological Survey presented papers at a meeting of the society giving data showing why the present location of the stations was of best value to the State.

As a further index of the society's connection with municipal affairs, shortly after the election of the present Mayor, a letter was addressed to him recommending that the departments handling engineering questions be headed by engineers.

In conclusion, Mr. Hanlon stated that the training of the engineer fits him naturally either for official or advisory services in the economical administration of the departments of a municipality, and it is not going beyond the confines of the requirements of public opinion to predict that soon all municipal activities will be placed under strict professional supervision.

ST. LOUIS, DECEMBER 18

The St. Louis Section of the Am.Soc.M.E. held a very successful fellowship dinner at the American Hotel Annex on December 18. The speaker of the evening was Paul Brown of the St. Louis *Republic*, who spoke on The Economic Development of the American Railway. At the close of Mr. Brown's remarks a roll call was held and each man stated briefly what work he is now engaged in, and several members gave interesting short talks. About forty members and guests were present.

BUFFALO, JANUARY 5

At a meeting of the Buffalo Engineering Society on January 5, Dr. John A. Mathews, Mem.Am.Soc.M.E., and president and general manager of the Halcomb Steel Company. of Syracuse, gave a talk on Iron in Antiquity and Today. He said that iron was probably in use some 5,000 years ago, and that Asia and India were probably the places where iron was first used.

From Belgium, he said, came the first steel rails and the first locomotive. The world owed much to the scientific advances made by the metallurgists of England. In America little attention had been paid to the scientific side; more time had been devoted here to mining and manufacture of iron and steel products.

Dr. Mathews called attention to the advances in the industry being made in China, Japan and India, in which countries evidently remarkable iron works are in operation. He said also that the introduction on the Pacific Coast of America of iron and steel products from Asia was a direct challenge to American industry.

Thos. E. Durban, chairman of the American Uniform Boiler Law Society, described the A.S.M.E. Boiler Code and urged the members present to use their influence to have the Code adopted by New York State.

BOSTON, JANUARY 14

At a meeting of the Boston Section of the Am.Soc.M.E. on January 14, Dr. Ira N. Hollis, Mem.Am.Soc.M.E., and president Worcester Polytechnic Institute, gave an address on Naval Lessons of the Great War for America, and gave an analysis of the elements that make up a fighting fleet, including the submarine and the aeroplane, the battleship, the armored cruiser, and the scout, and described methods of destroying them.

Dr. Hollis pointed not only to the necessity but also to the inevitableness of preparedness. He spoke in disfavor of prohibitive regulations in the Navy, considering that such were

not necessary except in the case of certain plans and devices that need to be kept secret. He also commented on the frequent failure to give publicity to naval matters with the proper accuracy, stating that this lack of care sets up an undesirable screen between the people and the Navy. He advocated coördination in the various Navy Departments, and also such education of enlisted men as would increase their morale and make them contented and valuable units in the service.

CHICAGO, JANUARY 14

At a meeting of the Chicago Section, January 14, P. A. Boeck, mechanical engineer of the Kieselguhr Company of America, presented a paper on High Temperature Insulation. H. M. Montgomery, Chairman of the Section, presided and introduced the speaker.

Mr. Boeck said that the problem of prevention of heat losses has been the subject of considerable investigation in certain industries, more especially in the applications of cold storage installations and of steam lines. He reviewed the mechanics of heat flow, the requirements of insulators, the amount of insulation necessary, and other phases.

He then described the insulating properties of Celite, a siliceous mineral occurring on the Pacific Coast in practically a pure state. It contains numerous hollow cells, and weighs in its natural rock-form, air-dried, from 25 to 30 lb. per cu. ft. When ground properly, it weighs 8 lb. per cu. ft., and has a thermal insulating power about equal to that of cork, or from 9 to 10 times that of ordinary firebrick; the ground material is called Sil-O-Cel powder. He concluded with examples of the use of this material.

A brief discussion, complimentary to the speaker, followed the presentation of the paper.

LOS ANGELES, JANUARY 18

About 30 members attended the meeting of the Los Angeles Section held on January 18. W. W. Smith reported on his trip to the Conference of Local Sections in New York, explaining to the members in a general way, certain proposed changes in the method of handling Society affairs.

The question of affiliation and coöperation with the local sections of similar organizations was very ably discussed by various members. It was further proposed to attempt the formation of an Engineers' Club in Los Angeles, this club taking in the various technical societies.

Following this discussion, F. W. Harris, Mem.Am.Soc.M.E., talked briefly on the subject of Patents, outlining the general theory and procedure in handling patent cases, and the general defects of the patent system which is in operation at the present time.

ST. LOUIS, JANUARY 19

A joint meeting open to all the Associated Engineering Societies was held at the Engineers' Club of St. Louis on January 19. Carl Barth, Mem.Am.Soc.M.E., spoke on Certain Phases of Scientific Management of Machine Shops. He paid tribute to the work of the late Dr. Frederick Taylor, and emphasized particularly the necessity of standardization of equipment before attempting so-called efficiency work in any of its branches. Attention was called to the possibilities of the application of mathematics to nearly all machine shop problems. Mr. Barth was for many years Dr. Taylor's principal assistant in the efficiency movement, and is one of the foremost experts on machine shop efficiency in this country. Previous to the meeting, an informal dinner was tendered Mr. Barth and his friend, Dr. Rover, at the West End Hotel.

STUDENT BRANCHES

CASE SCHOOL OF APPLIED SCIENCE

The December meeting of the Case School of Applied Science Student Branch was held on the fifteenth of the month. F. R. Hutchinson, of the East Ohio Gas Company, gave a paper on Gas for House Heating, which covered the cost and application of heating homes by gas. Figures showing the comparative costs of operation of the different systems used were presented, together with illustrations of the houses where the tests were performed, and the various forms of heating plants on which the figures were based.

The January meeting of the branch was held on the fifth. Following a supper, J. H. Stratton, Mem.Am.Soc.M.E., of the Wellman-Seaver-Morgan Co., gave an illustrated talk on Ore Unloading Machinery on the Great Lakes. Mr. Stratton reviewed the history of the ore business and gave statistics showing the increase in ore shipments from the start down to the present time, showing how the meager means of transportation in early times were soon replaced. From the horse and wagon, down to the Hulett unloader of to-day, the various appliances used were shown. Details of many types of grab-buckets were given, and their advantages and disadvantages summarized. The speaker then told of the many ways in which the late Alexander Brown had advanced the methods of ore unloading, and closed his talk with a short summary of the great transportation problems of the future.

COLORADO AGRICULTURAL COLLEGE

A meeting of the Colorado Agricultural College Student Branch was held on January 10, at which N. L. Chatfield, a travelling engineer connected with the Great Western Sugar Company, gave an interesting talk on the Manufacture of Sugar from the Mechanical Standpoint. In his discussion pieces of apparatus used and in many cases the construction of each were described, and a review of all the processes was given.

COLUMBIA UNIVERSITY

A meeting of the Student Branch of Columbia University was held on January 14, at which Neil MacCoull, Jr., gave a talk on Aeroplane Design. With the aid of a number of lantern slides, he showed the development of the modern type of aeronautical machine, and described the design of its various parts.

He said that in military uses the climbing speed is often of more importance than the horizontal speed. The depth of the wing determines the lifting power. In body design two factors are determining ones; wind resistance is a very important factor, and for military use the position of the guns and their angle of fire are of extreme importance. As to engine design, recent developments have shown that the stationary, water-cooled cylinder engine is the best for machines that are to make flights of more than about two hours.

LEHIGH UNIVERSITY

On December 15, the engineering societies of Lehigh held a joint meeting, at which R. S. Perry, president of the Alumni Association of the University, spoke on the Function of Engineering and Industrial Activities as Coefficients of Preparedness. He said that there is a vast difference between modern and earlier warfare. Men reared in the Navy and the Army, and who have trained themselves for war, had an idea of what modern war would be like, but their wildest imagination never reached what we are beginning to realize modern warfare is. Former wars were small affairs compared with the present. In our own Civil War the armies went into winter quarters, while now fighting is carried on through the winter. Former wars used only a fraction of the explosives which are used to-day. The food supply was heretofore obtained from entirely local sources. Through the present war there has been an abnormal drain on normal industries, and also on abnormal ones, such as industries making munitions. He then cited examples to show the effects of the European war on the industries of the great nations.

LELAND STANFORD UNIVERSITY

At a meeting of the Leland Stanford University Student Branch held on December 1, Horner Ling read a very interesting paper on Mechanical Railway Signals, in which he discussed the development of various types of railroad semaphore signalling devices, and described the signal practice of various railway companies and the form of signals which they use. He explained also the working of the block system used by the Southern Pacific Railroad, both for single and double track service.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

At a meeting of the Student Branch of the Massachusetts Institute of Technology held on January 5, Clarence B. Sawyer, salesman for the Dodge Sales and Engineering Company, addressed the members on Rope Drive, laying special emphasis on the comparative merits of the American and English systems.

PENNSYLVANIA STATE COLLEGE

A meeting of the Student Branch of the Pennsylvania State College was held on January 13, at which the following officers were elected: G. Jeffery, president; O. L. Stevens, vice-president, and G. S. West, secretary.

POLYTECHNIC INSTITUTE OF BROOKLYN

The Student Branch of the Polytechnic Institute of Brooklyn held a very interesting and instructive meeting, at which a lecture was given by J. J. Ruckes, Jr., Mem.Am.Soc.M.E., on the Manufacture of Paper and Wood Pulp. The talk dealt with the production of medium quality paper such as is used for ordinary commercial work. The lecturer described the two principal methods of preparing the wood pulp and the most widely accepted process of turning it into paper.

The raw materials usually consist of poplar, spruce, or pine trees, while for some cheaper grades various straws and bamboos are used. Entering the pulp mills, the wood is cut into 2-ft. lengths, separated from the bark, and ground or crushed by chippers. The crushed wood is then screened to remove knots and slivers. The refuse and waste from these operations are used as fuel for the furnaces. There are two methods of preparing the pulp, the sulphite method utilizing sulphurous acid, and the soda process using caustic soda. The finished pulp is placed in a beater and mixed with the requisite coloring matter, sizing and clay. The latter is introduced to give the paper weight and good inking qualities. The pulp then passes through a refiner and screen to a Fourdrinier machine containing a wire cylinder over which the pulp plays. This separates much of the water. The layer of pulp issuing from this machine is next pressed and passed through dryers, which further reduce the moisture contents. The final operations consist of calendering and winding. It has been estimated that, in paper making, it requires, for the various operations, 56,000 gallons of water to prepare one ton of finished product.

The lecture was illustrated by slides and photographs, and samples of pulp and paper were exhibited.

PURDUE UNIVERSITY

A meeting of the Purdue University Student Branch was held on January 11. Thomas T. Eyre, Mem.Am.Soc.M.E. and head of the Engine and Boiler Department of the University, spoke on the Effects of Early Cut-off upon Wire Drawing in Steam Engines. Professor Eyre has arrived at the results he gave after much work, involving a great number of experiments. He illustrated his lecture by means of Zeuner and other valve diagrams, sample indicator cards, velocity curves, and different types of governors.

STATE UNIVERSITY OF KENTUCKY

At a meeting of the State University of Kentucky Student Branch on January 14, the report of the Chicago Association of Commerce Committee on Investigation of Smoke Abatement and Electrification of Railway Terminals was discussed. W. H. Dix, M. G. Horton, A. B. Huff, R. E. Hundley and Miss Margaret Ingels presented an outline of the report giving the reasons for making the investigation, the data secured, the results obtained as shown graphically, and the conclusions drawn from these factors. This report is especially interesting to the seniors, who make annually an inspection trip to Chicago and vicinity. The information given in it on the industrial and transportation conditions in Chicago, the problem of purifying the atmosphere and the solution of the Chicago transporation difficulties, are all of great interest in instructing them as to what to look for on the inspection trip.

UNIVERSITY OF MICHIGAN

The University of Michigan Student Branch held a "get-together" smoker on December 3, at which a concentrated effort was made to increase the membership of the branch. Prof. J. R. Allen and W. F. Verner, Members of the Am.Soc.M.E., each gave short talks on the benefits of membership in the Society and the advantages of meeting members of the mechanical engineering profession.

Commander J. H. Rowen, U. S. N. (retired), gave a paper in which he discussed a new kinetic theory of the relations of spectra to each other, and told of the work being done to discover waves connecting the light and heat spectra.

On December 17, H. H. Esselstyn, Mem.Am.Soc.M.E., and chief construction engineer for the Eastern Michigan Edison Co., gave a talk on Reminiscences of Engineering Work. Afterwards Mr. Esselstyn discussed, in answer to questions, some of the tentative plans for additions to the Connors Creek Plant of the Detroit Edison Company, including the installation of a 40,000 kw. Curtiss turbine.

UNIVERSITY OF MINNESOTA

The regular meeting of the University of Minnesota Student Branch was held on January 8, at which the following officers were elected: G. A. Ek, president; I. L. Johnson, corresponding secretary; C. Swenson, recording secretary, and C. I. Guggisberg, treasurer.

Prof. W. H. Kavanaugh, Mem.Am.Soc.M.E., and head of the experimental engineering department of the University, gave an address on the Annual Meeting of the Society, 1915.

UNIVERSITY OF MISSOURI

The regular meeting of the University of Missouri Student Branch was held on December 2. Prof. E. R. Hedrick, of the Mathematics Department of the University, spoke on Graphical Analysis. He discussed principally the straight line graph, particularly that plotted on logarithmic paper. He demonstrated the value of logarithmic paper for finding the correctness of assumed equations for empirical curves. He pointed out that it was easier to tell whether points lay on a straight line, when plotted on logarithmic paper, than whether they conform to a certain curve when plotted on common coördinates.

At a meeting of the branch on January 6, the subject of Different Types of Present Automobile Construction was discussed by F. Nelson Westcott, I. O. Royse, R. M. Lotz and Fred P. Hutchinson. The various types of motors, including the four- and six-cylinder, etc., and the Knight motor were discussed and compared. The new model Stanley steamer car was diagnosed and compared with former steam cars and with present gasoline cars with which it has to compete.

UNIVERSITY OF NEBRASKA

A meeting of the University of Nebraska Student Branch was held on December 7. Prof. C. L. Dean, Associate Professor of Mechanical Engineering of the University, gave a most interesting lecture on the Development of the Modern Locomotive.

Professor Dean said that because of the great field covered by this subject he could only touch the high spots, as any one phase might be worked up into a two or three-hour lecture. He first emphasized the increase in size, weight and speed of trains, necessitating larger and stronger engines, the engines themselves being increased in weight from 25,000 to 800,000 lb.; drawbar pull from 10,000 to 200,000 lb.; steam pressure from 125 to 320 lb. per sq. in., and having grate areas as large as 120 sq. ft. He then described devices for increasing efficiency, such as brick arches, superheaters, reheaters, feedwater heaters, mechanical stokers and valve gears.

He cited an example of a Mallet engine in which, with no superheater, 20 per cent of the steam was condensed in the

pipes before reaching the cylinder. Using a superheater placed in the path of the hot gases reduced the coal consumption 20 to 25 per cent without additional fuel, reduced the water consumption 25 to 35 per cent, increased the boiler pressure, reduced boiler maintenance, increased the boiler capacity without increasing the weight, and increased the hauling power 33 per cent.

WORCESTER POLYTECHNIC INSTITUTE

At a joint meeting of the Worcester Polytechnic Student Branch, the American Institute of Electrical Engineers, and the Civil Engineering Society, on January 10, 1916, Prof. George F. Swain, of the Harvard M. I. T. Engineering School, delivered an address on Water Power in the United States. In his introduction, Professor Swain spoke of the movement for the conservation of our natural resources, including forests, minerals, lands and water. The fact was brought out that the conservation of water power is really a triple one. Coal not used is not wasted, but, on the contrary, water power not utilized is lost; and by neglecting its use and allowing coal to replace it, we are wasting, it is estimated, over nineteen million horsepower a year which is economically capable of development. By placing dams and locks, we not only make the development of power possible and save a tremendous amount of coal, but we may also improve the navigation in a river. This possibility of wonderful conservation has not been as fully recognized in our country as in many countries of Europe, and our national laws and public sentiment are more prone at present to discourage than to encourage attempts to bring about a saving of this power, which would mean a decrease of three hundred million dollars in our annual coal bill. The disadvantages of very high initial investment and uncertainty of water power have caused many promoters and investors to place their interests in steam rather than in water power plants.

The speaker discussed the law of riparian rights, which states that every owner of land bounded by a stream has a right to the flow of the water past his land so long as he does not hinder this same privilege of the owner below him or pollute the stream. In cases in which the Government has built a dam for the improvement of navigation, the question has been raised whether the power developed belongs to the Government or to the parties whose land borders on the river above the dam. It is claimed by some that the Government owns the power, since it made the development of power possible, while others claim that the Government can lawfully use the water for navigation only, and that by the law of riparian rights, the power belongs to those through whose land the river flows.

The fact was brought out that in some instances when private parties have secured permits to build dams in rivers they have not only been required to light the dam, furnish land to the Government for canals, build locks and operate them, etc., but have been required to pay to the Government certain amounts of money for the privilege. In view of the fact that these dams improve the navigation of the river, it does not seem that the encouragement to conservation offered by the National Government is very overwhelming, and it is hoped that legislation will greatly improve the present conditions.

EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month. The notices now appear in the Employment Bulletin in a form which indicates the classification.

POSITIONS AVAILABLE

The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer. Stamps should be enclosed for forwarding applications.

461 Engineer-Designer on multiple effect evaporators and equipment for chemical plants; man must be well recommended, of good character and exemplary habits, good appearance and address. Permanent connection at adequate salary. Location Middle West.

462 Young Engineer with one or two years shop experience for efficiency department in large corporation; technical graduate preferred but not absolutely essential; require man who is tactful in handling workmen and who has a well developed analytical mind. Location Western New York. Apply by letter, name confidential.

1 Electrical Engineer with good knowledge of physics, for experimental work in laboratory of large electrical manufacturing company in the East. Preferably a technical graduate. Salary $20 to $30 a week, depending on ability.

2 Young Mechanical Graduate, with one or two years experience in machine shop practice. Location New England.

4 Production Engineer for progressive power laundry in important city near New York. Ability to select the proper type of employee for a given task, and to develop and maintain to the maximum, individual and departmental efficiency; general mechanical and electrical training; practical experience in laundry production. Opportunity is afforded for lucrative and continuous employment with assurance of advancement.

5 Manager of Sales, to handle product in New England, the Eastern, Middle and Atlantic Coast and Southern States, for up-to-date cement plant equipped with the most modern type of machinery.

6 Detail Draftsmen, experienced, for an industrial concern. Men preferred who have had three to ten years experience in steel mills of smelter plants. Apply by letter.

7 Professor of electrical engineering of high grade technical capacity, experience in practice, teaching ability, vigor, personality. One of high standing among engineers and recognized as an authority. Location Middle West.

8 Assistant in purchasing department of concern handling purchases from $3,000,000 to $4,000,000 per annum; principal commodities, plates, shapes, bars and allied lines; coal, coke, pig iron and high and low pressure fittings. Man preferably between the age of 28 and 35, and one who has had rolling mill experience. Applicants must state age, nationality, whether married or single, by whom employed and over what periods. All references and communications will be treated confidentially. Location New Jersey.

9 Young Engineer between 22 and 24 for some designing and office work and part time on outside sales wanted by galvanizing concern. Location New York.

16 Young Technical Graduate for general sales office work such as estimating, data, correspondence and possibly publicity work, for turbine company in New England; salary about $1,000.

17 Engineer speaking fluently technical French and English wanted in iron and steel business; familiarity with manufacture of rails. Attractive salary to the right man. Eastern location.

20 Testing Engineer wanted, who is familiar with power plant conditions and is capable of assembling and installing recording meters and power plant instruments measuring flow of steam, water and gases. Young technical graduate with one to three years experience in machine shop and power plant work preferred. Location Maryland.

21 Foundry Superintendent. Energetic and aggressive man is desired to take charge of a non-union foundry located in the Central West, and pouring between 400 and 800 tons per month, on medium and heavy engine and blower work; favorable opening for a high-grade man. State experience and salary expected.

22 Task Setter, some experience in time study and drafting. Salary $75 to $100 a month. Location Maine.

23 Mechanical Engineer with factory experience, able to work out problems in mechanical handling of materials, and in installation of machinery generally. Location Cleveland.

25 Assistant Purchasing Engineer for the inspection of incoming materials for Massachusetts manufacturer of small electrical apparatus; applicants thoroughly familiar with electrical, insulating and composition casting materials, with practical knowledge of metal working machinery, etc. In reply, confine answer to the following: Age, nationality, education, practical experience, salary expected, when at liberty.

26 Business Associate Wanted; a young man of good business habits having $5000 to invest in a newly established business in which profits are perfectly satisfactory, but present resources inadequate to cover the whole country.

28 Production Engineer to take charge of department, operate it by present methods, and to develop it as fast as possible into an up-to-date planning department. Also time study man. State age, education, experience, salary expected, name references and send photograph.

29 Safety Engineer for Massachusetts factory employing 1500 hands; must be familiar with machine tool guards of all kinds and factory safety devices; one who has had theory and practice combined and able to design and standardize guards. Experience along electrical work preferred. Applicants requested to furnish in brief the following data: Age, nationality, experience, references, salary.

34 Steam Specialty Salesman, or others, who desire to handle a line of vacuum heating specialties on a commission basis, can secure restricted territory to represent manufacturers. Representatives wanted in Portland, Maine; Boston, Pittsburgh, Cincinnati, Detroit, Chicago, St. Louis, Milwaukee and other large cities. Apply through Society.

36 Partnership: a consulting engineer of New York, with practice in a special field which can be greatly extended, desires to take into partnership an engineer experienced in vibration causes in buildings, who can invest some money and with qualifications for conducting investigations in the fields of physics and applied mechanics. Apply by letter.

37 Cadet Engineers: recent graduates of technical schools, for work in connection with study of central station power house operation, in line of improving operation and methods. Salary starts at $40.00 per month and increases to a maximum of $75.00 per month. Further advance entirely a matter of personal ability to fit into the organization. Location New Jersey.

38 Mechanical Draftsman, capable and qualified in design of special heavy machine tools. Location Pennsylvania.

39 Young Engineer, competent and familiar with the practical use of pulverizing coal for fuel. Name and location confidential. Apply by letter.

41 Engineer familiar with operation and construction of chemical plants.

42 Salesman with technical education as mechanical engineer to become head salesman of heavy capacity automatic scales for factory and warehouse uses; man between 30 and 40; traveling position; one-third of time at factory in Middle West, two-thirds in field. Salary liberal. Apply by letter.

47 Young Technical Graduate, with one or two years experience, excellent opportunity to enter a machinery concern with view of learning the business. All replies held confidential. Location Rhode Island.

MEN AVAILABLE

The published notices of "men available" are made up only from members of the Society. Notices are not repeated in consecutive issues of the Bulletin. Names and records are kept on the office list three months, and at the end of such period if desired must be renewed.

Members sending in notices for the Men Available section are particularly requested in the future to indicate the classification under which they desire their notices to appear.

B-43 Works Manager, 20 years experience in manufacturing firearms, typewriters, automobiles, power house equipment, etc., wishes to make a change. At present employed.

B-44 Chief Operating Engineer or Superintendent of Power with 14 years experience, good floor machinist and erecting man. Several years satisfactory service with each of last two employers as chief engineer. Experienced in steam, gas and Diesel engines, a.c. and d.c. current, air compressors and hydraulic machinery. Good organizer; at present employed. Location immaterial.

B-45 Plant Engineer, technical graduate, age 30, nine years experience as plant engineer on construction and repair of mill buildings and selection, layout, installation and maintenance of equipment in various lines, wishes position with manufacturer. At present employed.

B-46 Mechanical Engineer, Consulting Engineer and Executive, college graduate, owning valuable patents on poppet-valve engines (several engines in successful operation), would consider investment and connection with engineering, contracting or consulting firm, or to act as representative in New York, preferably where combination of engineering business and organization ability is demanded. English, German and French correspondent.

B-47 Mechanical Engineer and Superintendent. M.E. graduate, age 33, seven years experience with consulting engineer on the layout and purchase of complete mechanical equipments, including power plants, heating and ventilating systems, wiring, fire protection, conveyors, manufacturing apparatus, etc., for factory, office and mercantile buildings; last three and one half years in full charge of construction work, previous five years machine shop and drafting experience. Good executive ability and knows how to get results, desires position with corporation or engineering firm.

B-48 Sales Engineer, Manager or Superintendent. Worcester Polytechnic Institute graduate, M.E., age 36, thirteen years practical experience on pumping machinery, air compressors, internal combustion engines, pressure tanks, overhead tanks and towers, design of pumping combinations and managing contract sales; wide experience handling engineering correspondence. At present employed as executive in contracting concern but open to make new connection at once. Location preferred New York or vicinity.

B-49 Chief Draftsman or Assistant Chief Engineer. Mechanical and civil engineer, admitted to both degrees, twenty years experience in industrial works and waterfront engineering; drafting, designing and supervising construction work, desires position as chief draftsman or assistant to chief engineer.

B-50 Research or Mechanical Engineer. Graduate M.E., eighteen years experience, four years as field expert and superintendent of erection of steam engines in public service stations. Eight years as chief engineer, designing gas and steam engines, pumps, hoists and special machinery and conducting tests and thermodynamic investigations, also experienced in design of automatic machinery, desires a position as research or mechanical engineer. At present employed.

B-51 Manager, Chief Engineer or Sales Engineer. Engineering graduate, age 33, with broad experience in boiler manufacture and general plate work. Good organizer. Salary $3000.

B-52 Printing Press Expert and Designer, fifteen years experience, successful designer of automatic machinery for

paper goods, boxes of any description, paper bags, envelopes, corrugated board containers, folding boxes, lace, labels, tags, etc. Experienced executive and organizer, solicits correspondence with Pacific Coast concern, machine shop, publishing house or paper goods manufacturer with a view of introducing up-to-date methods, machinery and specialties. Salary to start $3000. Partnership considered.

B-53 Assistant Chief Engineer or Chief Designer. Graduate mechanical engineer, age 31, eight years designing experience in oil engines (Diesel oil engines, European and American practice), large variety of special and automatic machinery manufactured on the interchangeable basis, desires responsible position as assistant chief engineer or chief designer with reliable firm building Diesel oil engines, or concern contemplating building these prime movers. Salary $2000; at present employed.

B-54 Sales Engineer. Graduate mechanical engineer, age 35, competent to handle sales either by correspondence or personal interview and intimately acquainted with modern power plant practice, thirteen years experience handling sales of the following classes of equipment: pumping machinery of all classes, steam, power and centrifugal; condensing apparatus of all types; feed water heaters; internal combustion engines; steam engines and air compressors for all services. At present employed but open for engagement March 1. Location immaterial.

B-55 Executive for Automatic Machinery. Member, technical education together with ten years practical experience in manufacturing duplicate parts on the interchangeable basis, also familiar with design of tools, jigs, fixtures, etc., for this work, wishes to communicate with reliable firm desirous of securing the services of a live up-to-date executive, especially trained in handling difficult problems in all kinds of automatic machines and the die-casting of intricate parts.

B-56 Factory Manager, Engineer or Production Manager, age 37, sixteen years automobile and gas engine experience, practical manager and able executive, well acquainted with the trade, has worked through all departments of a manufacturing business and thoroughly understands all details, is open for a position.

B-57 Sales Manager or Manufacturers' Representative, ten years successful experience in sales engineering, graduate mechanical engineer, age 35, large industrial and engineering acquaintance in Eastern territory.

B-58 Technical Graduate, age 27, energetic and tactful, three years experience in machine shop, fifteen months drafting room designing power plants, two years testing and general operation in a large turbine station. Especially familiar with surface condensers. At present employed but wants to change.

B-59 Factory Manager, age 33, fourteen years experience in handling men and affairs, thoroughly trained in machine shop and foundry management and business affairs; for the past five years engaged in operating large gasoline engine factory in Middle West, desires to make a change.

B-60 Designer, Layout Draftsman, Mechanical Engineer, now in charge of drawing office in Boston, desires position as engineer or draftsman in East or Middle West. Salary $125-$150.

B-61 Munitions Manufacturing Expert. Graduate United States Naval Academy, age 33, married, with several years experience in engineering executive position with a Public Service Corporation, has lately designed large machine shop and heat treating department for the manufacture of large calibre, high explosive shells, at the same time served in a consulting capacity on power plant, construction work and factory organization for the same company. Knows where lathes, electrical and furnace equipment for large calibre shells may be purchased, as well as a suitable manufacturing plant with excellent rail and water shipping facilities.

B-62 Representative for the Far East. Japanese graduate of electrical and mechanical schools, connected with telephone and railway companies of New York, wishes to communicate with American firms planning to develop their business in Japan or China. Will consider agencies.

B63 Mechanical Engineer with shop, field, designing, sales, executive and business experience. Specialties, power plant, heating and ventilating, desires responsible position with a view to permanency.

B-64 Manufacturers' Representative, graduate of Massachusetts Institute of Technology, has a large experience in the selling of building materials and an extensive acquaintance with architects, engineers and contractors, wishes to represent as sales engineer in New England, with headquarters in Boston, manufacturing concerns specializing in material, either mechanical or electrical, connected with building operations.

B-65 Specialist in Steam Engineering and Power Plant Equipment, Associate member A.I.E.E., conversant in practical efficiency engineering methods, will consider one or two year contract in investigating, organizing or executive capacity. Available July 1, 1916.

B-66 Pulp or Paper Mill Engineer, with thorough experience in pulp and paper mill engineering, including developments, reports, designs, specifications and contracts for buildings, power requirements and manufacturing equipment, capable of assuming responsibility and control, desires position.

B-67 Manufacturing Engineer, six years manufacturing experience, at present employed, desires to locate in New York or vicinity.

B-68 Factory Maintenance, Assistant to Executive, or Purchasing. American graduate mechanical engineer desires position with an industrial concern in an executive capacity. Has handled men and had charge of power plant investigations, testing department and erection work; energetic and reliable. At present employed as chief inspector in large concern.

B-69 Factory Manager, Superintendent or Efficiency Manager, technical graduate, M.E., age 30, ten years experience in costs, statistics, production work, office and factory management, can refer to several successful concerns as to ability and results obtained as an organizer.

B-70 Executive, member with wide experience in industrial construction, as executive in responsible control of purchasing, organization, and operation of work in the field.

B-71 Assistant to Machine Designer or Consulting Engineer, mechanical engineer, experienced machine designer, thorough knowledge of patents, desires association with salary about $1200 per annum.

B-72 Assistant Foundry Superintendent of an iron foundry. Graduate mechanical and metallurgical engineer, having experience in all branches of foundry practice, including loam, dry and green sand molding, machines, the cupola, mixtures, etc. Location immaterial.

B-73 Assistant to Consulting Engineer. Cornell M.E., 1912, age 27, past three and one half years employed as mechanical engineer in an Eastern plant, has made plans for new buildings, machinery layouts and superintended installation of all mechanical and electrical apparatus. Location preferred New York.

B-74 Assistant to Consulting or Contracting Engineer, mechanical engineer, technical graduate, age 28, has had charge of responsible mechanical and electrical engineering work for consulting engineer, desires position along similar lines. Location preferred in or around Philadelphia.

B-75 Engineer and Executive, mechanical engineer, executive and representative ability, twenty-five years experience in general machinery and machine tools, desires position. Has been granted several patents.

B-76 EXECUTIVE, graduate M.E., age 38, fifteen years engineering experience, of which nine was in the executive capacities of chief draftsman, chief engineer, assistant works manager, and works manager with two big corporations and operating spelter works, machine shop and ship yards. Has specialized in heavy hydraulic presses, Diesel oil engines, blast furnace gas engines, suction dredges and ships, metallurgy of steel, and electric furnaces, shop layouts and organization. Has traveled extensively, conversant with European and American business methods, speaks German, French, English, Spanish and Russian, desires position where broad theoretical and practical experience could be advantageously applied.

B-77 ASSISTANT TO SUPERINTENDENT, Junior, graduate Massachusetts Institute of Technology, five years experience as assistant to the mechanical superintendent in a manufacturing plant having an up-to-date machine shop, thoroughly versed in tool and plant maintenance, desires position.

B-78 EXECUTIVE AND PRODUCTION ENGINEER, age 34, married, technical man, last nine years engaged as executive and production engineer for large manufacturing concern, has reached limit of present position and desires to become associated with live concern which needs an executive capable of producing systematic results at maximum efficiency.

B-79 ASSISTANT TO SUPERINTENDENT OR WORKS MANAGER. Mechanical and electrical engineer, technical graduate, energetic and possessing knowledge of shop costs, wage systems and efficiency methods. Has worked in engineering department, drafting room and as practical machinist with large concern manufacturing refrigeration and electrical machinery, also chemical plant (pigment manufacture) experience, desires position as assistant to superintendent or works manager of a growing concern. Salary commensurate with position. Location preferred Middle West.

B-80 IRON, STEEL AND COKE ENGINEER. Member with twenty-five years practical experience in the manufacture of iron and steel, and eight years in the manufacture of by-product coke, invites correspondence or conference with parties desiring mature advice on the improvement or addition to plants; on efficiency, metallurgical or heat-treatment problems in iron and steel manufacture; on the arbitration of technical disputes between producers and consumers; on patent litigation, etc. Prefer to work in coöperation with engineering staff of companies, thus attaining maximum benefits at minimum expense.

B-81 OFFICE MANAGER OR ASSISTANT TO MANAGER, open for temporary engagement in connection with sales or purchasing; extensive experience in travelling for well known machine builders.

B-82 EXECUTIVE, graduate engineer, age 35, thoroughly experienced in all methods of scientific management. Previous work has been in the manufacture of hoisting and conveying machinery, textiles and fine stationery. Competent to take responsible executive position.

B-83 SUPERINTENDENT OR FACTORY MANAGER, mechanical engineer, graduate of Massachusetts Institute of Technology, seventeen years experience in manufacture of water tube boilers, also tanks, stacks and kindred products. Has also had considerable to do with general correspondence, purchasing, accounting and cost keeping and can produce results that count.

B-84 POWER PLANT SUPERINTENDENT. Graduate engineer, age 36, has had nine years power plant experience, capable of taking charge and running it (especially the boiler room), on an economical basis.

ACCESSIONS TO THE LIBRARY

A List of Books and Pamphlets Added During the Past Month to the Library of the Society and of the United Engineering Society, Engineering Societies Building, New York

ADDITIONS BY THE AM. SOC. M. E.

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

ACCOUNT OF AN EXCURSION FOR THE INSPECTION OF THE WORK OF AGRICULTURAL TRACTORS ON PRIVATE ESTATES IN THE SOUTH OF RUSSIA IN 1912, A. B. Treiwass and A. A. Baranovski. In Russian. *St. Petersburg, 1913.* Gift of Russian Department of Agriculture.

APPLICABILITY OF MOTOR-DRIVEN PLOWS IN RUSSIA, A. A. Baranovski. In Russian. *1915.* Gift of Russian Department of Agriculture.

BOOK OF DEFINITIONS AND STANDARD STOCK PARTS FOR USE OF OTIS ELEVATOR COMPANY, John H. Buckley. *1915.* Gift of author.

BUREAU OF FARM MECHANICS OF THE RUSSIAN DEPARTMENT OF AGRICULTURE. Proceedings, 1913, Tome V, pts. 6-8, 1914, Tome VI, pts. 1-6. *1914-15.* Gift of Russian Department of Agriculture.

BUSINESS OPPORTUNITIES OF LOUISIANA AND ADJACENT STATES, Geo. B. Davis. *New Orleans, 1915.* Gift of Ford, Bacon and Davis.

THE CONSERVATION OF ENERGY. A Plea for the language of experiment in the teaching of physics, W. S. Franklin and Barry Macnutt. Reprint from Bulletin of the Society for the Promotion of Engineering Education, vol. VI, no. 3, 1915. Gift of C. W. Rice.

COLUMBIA UNIVERSITY. Department of Physics. Four lectures on Mathematics, delivered in 1911, by J. Hadamard. Publication no. 5.

——— Eight Lectures on Theoretical Physics delivered in 1909, by Max Planck. Publication no. 3. *New York, 1915.* Gift of Department of Physics, Columbia University.

ECONOMIC ADVANTAGES RESULTING FROM PORT DEVELOPMENT. Geo. B. Davis. *New Orleans, 1915.* Gift of Ford, Bacon and Davis.

THE GOVERNMENT AND BUSINESS, S. O. Dunn. Gift of Bureau of Railway Economics.

HISTORY OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS FROM 1880-1915, F. R. Hutton. *New York, 1915.* Gift.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS. Twenty-seventh Annual Report, 1912. *Wheaton, 1912.* Gift of Society.

THE IMPERIAL VALLEY AND THE SALTON SINK, H. T. Cory, with introductory monograph, by W. P. Blake. *San Francisco, J. J. Newbegin, 1915.* Gift of H. T. Cory.

This is an account of irrigation and river control in the Colorado River delta, a reprint of a paper read before the American Society of Civil Engineers in January 1913, to which certain supplementary matter has been added. W. P. C.

INDIANA ENGINEERING SOCIETY. Proceedings of the 34th and 35th Annual Convention. *Indianapolis, 1914, 1915.* Gift of Society.

INDIANA SANITARY AND WATER SUPPLY ASSOCIATION. Proceedings of the 6th-8th Annual Convention. *1913-15.* Gift of Association.

MARINE AND STATIONARY DIESEL ENGINES, A. H. Goldingham. *New York, Spon & Chamberlain, 1915.* Gift of publishers.

There has been need for a handbook of the Diesel engine, as the literature on the subject has never been properly summarized. The present work is essentially a practical one, concise, and well illustrated. W. P. C.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION. Proceedings of 46th Annual Convention. *Reading, Mass, 1915.* Gift of Association.

THE MENACE TO NATIONAL PROSPERITY. An Address by Newman Erb. Gift of Bureau of Railway Economics.

MOTION MODELS; their use in the transference of experience and the presentation of comparative results in educational methods, Frank B. and Lillian M. Gilbreth. Paper presented before American Association for the Advancement of Science, Dec. 27, 1915. Gift of authors.

MOTOR CULTURE OF LAND, COLLECTION OF ARTICLES. In Russian. *1913.* Gift of Russian Department of Agriculture.

MOTOR TRACTORS AND PLOWS AT THE IV INTERNATIONAL AUTOMOBILE EXPOSITION IN ST. PETERSBURG. A. A. Baranovski. In Russian. *St. Petersburg, 1913.* Gift of Russian Department of Agriculture.

MOTOR TRACTORS FOR TRANSPORTATION OF HEAVY LOADS AND MOTOR PLOWS, AND ON TRACTORS AND FARM AUTOMOBILES. In Russian, from German. *St. Petersburg, 1912.* Gift of Russian Department of Agriculture.

NATIONAL ASSOCIATION OF STATE UNIVERSITIES IN THE UNITED STATES OF AMERICA. Transactions and Proceedings. vol. 13, 1915. Gift of Association.

NATIONAL COMMERCIAL GAS ASSOCIATION. Proceedings of the Tenth Annual Convention. *New York, 1914.* Gift of Association.

THE NEED OF EDUCATED MEN IN INDUSTRIAL AFFAIRS. Lecture at Cambridge University, May 15, 1911, Frank H. Taylor. Gift of author.

NEW ORLEANS SEWERAGE AND WATER BOARD. Twenty-ninth semi-annual report, 1914. Gift of Sewerage and Water Board.

NEW YORK STATE ENGINEER AND SURVEYOR. Annual Report 1914, vol. I. *Albany, 1915.* Gift of State Engineer and Surveyor.

PAVEMENT GUARANTIES, THEIR USE AND ABUSE, J. W. Howard. *Newark, 1907.* Gift of author.

PAVING BRICK THE NECESSITY OF UNIFORM QUALITY. Tests for high grade paving bricks, J. W. Howard. *New York, 1913.* Gift of author.

PERMANENT TARIFF COMMISSION. "A National Business Policy." Referendum of Commercial Organizations, 715 votes for 9 votes against. Gift of U. S. Chamber of Commerce.

PORTLAND CEMENT, CONCRETE PAVEMENTS, CAUSES OF FAILURES AND POSSIBLE BASIC DEFECTS, J. W. Howard. Gift of author.

PORTLAND CEMENT, CONCRETE ROADS FROM A QUARTER CENTURY PRACTICAL EXPERIENCE, J. W. Howard. *New York.* Gift of author.

PRINCIPLES AND PRACTICE OF COST ACCOUNTING, Frederick H. Baugh. *Baltimore, published by author, 1915.* Gift of author.

This is a treatise on cost accounting as applied to manufactured articles, and treats of the basic principles, and their application in a general manner. W. P. C.

PROHIBITION MOVEMENT, Percy Andreae. *Chicago, 1915.* Gift of author.

PROGRAMS AND METHODS OF TESTING AGRICULTURAL MACHINES AND IMPLEMENTS, Book I-III. In Russian. *St. Petersburg, 1911, 1912, 1914.* Gift of Russian Department of Agriculture.

PSYCHROMETRIC TABLES FOR COOLING TOWER WORK. Steam Tables for Condenser Work, ed. 3. (1 vol.) *Carteret, N. J.* Gift of Wheeler Condenser and Engineering Co.

RAILWAY MOTOR CARS, LIST OF REFERENCES, PREPARED BY THE BUREAU OF RAILWAY ECONOMICS, Nov. 30, 1915. Gift of Bureau.

RELATION OF THE RAILROAD AND ITS SECURITIES TO LAND VALUES, Fairfax Harrison. Gift of Bureau of Railway Economics.

SAFETY IN THE FOUNDRY, Magnus W. Alexander. *Chicago National Founders' Association, 1915.* Gift of publisher.

The Committee on Safety and Sanitation of the National Founders' Association have carried out investigations for two years, and this book, written by the Chairman of that Committee, is the result. It is profusely illustrated. W. P. C.

THE SECOND LAW OF THERMODYNAMICS, W. S. Franklin and Barry Macnutt. Reprint from Bulletin of the Society for the Promotion of Engineering Education, vol. VI, no. 3, 1915. Gift of C. W. Rice.

SOME TRADE SCHOOLS IN EUROPE, Frank L. Glynn. U. S. Bureau of Education, Bulletin no. 23. *Washington, 1914.* Gift of F. L. Glynn.

STREET PAVING AND MAINTENANCE IN EUROPEAN CITIES. A report by Henry Welles Durham. Dec. 31, 1913. *New York, 1913.* Gift of President of the Borough of Manhattan.

STRUCTURE AND PROPERTIES OF THE MORE COMMON MATERIALS OF CONSTRUCTION, G. B. Upton. *New York, John Wiley & Sons, 1916.* Gift of publishers. Price $2.50 net.

The work is restricted almost entirely to the theoretical discussion of the subject. It is an outgrowth of lectures given at Cornell University to laboratory students. W. P. C.

TESTING OF THE COMNICK MOTOR PLOW, A. B. Treiwass. In Russian. *1915.* Gift of Russian Department of Agriculture.

THE TESTING OF THE HART-PARR TRACTOR, I. B. A. Lintvareff. In Russian. *1915.* Gift of Russian Department of Agriculture.

THE TESTING OF THE HOLT CATERPILLAR TRACTOR, B. A. Lintvareff. In Russian. *St. Petersburg, 1914.* Gift of Russian Department of Agriculture.

TESTS OF TRACTORS AT THE SREDNE ROGATSKI FARM OF THE BUREAU OF FARM MECHANICS, N. Morozoff. In Russian. Gift of Russian Department of Agriculture.

TRAVELING ENGINEERS' ASSOCIATION. Proceedings of the 23d Annual Convention, 1915. *Buffalo.* Gift of Association.

TREATISE ON SAFETY ENGINEERING AS APPLIED TO SCAFFOLDS. Hartford, 1915. Gift of Travelers' Insurance Company.

U. S. ARMY. The Service of Information. *Washington, 1915.* Gift of U. S. Army.

U. S. INTERSTATE COMMERCE COMMISSION. Fourth Annual Report of the Chief Inspector of Locomotive Boilers, 1915. *Washington, 1915.* Gift of U. S. Interstate Commerce Commission.

U. S. LIGHTHOUSES COMMISSIONER. Annual Report, 1915. *Washington, 1915.* Gift of U. S. Lighthouse Board.

WHAT IS THE MATTER WITH RAILWAY REGULATION, S. O. Dunn. Reprinted from North American Review, Nov. 1915. Gift of Bureau of Railway Economics.

EXCHANGES

NATIONAL ASSOCIATION OF COTTON MANUFACTURERS. Transactions, no. 98, *Boston, 1915.*

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS TRANSACTIONS, vol. XXXI. *Newcastle-upon-Tyne, 1915.*

U. S. NAVAL OBSERVATORY. Annual Report, 1915. *Washington, 1915.*

THE W-PVT CHART, Merl R. Wolfard and Charles K. Carpenter, *New York, John Wiley and Sons, 1915.* Gift of publisher. Price 50 cents.

This chart contains several novel features. The area beneath an exponential curve has been integrated by the use of a suitable plotted scale so that the external work done on or by any gas may be read directly from the chart for any ratio of expansion or between any desired pressure limits. The external work done by the Rankine Cycle in a steam engine or by any similar cycle can be obtained directly in foot pounds. The chart can be used directly no matter in what units of pressure, temperature, or volume a problem may be stated. The chart is separated into two quadrants by the use of a heavy diagonal line only, so that the PV quadrant is brought into close juxtaposition with the TV quadrant, which enables one to determine the pressure, temperature, and volume relations throughout any gas engine or air compressor cycle. Brief instructions are given for the use of the chart and several examples taken from actual engineering practice are given illustrating the methods of using the chart which, by the way, may be used for obtaining the cube, cube root and the 3/2 or 5/2 power or root of any number. It is plotted on logarithmic ordinate paper which was engine divided to a 10 in. base. G.

TRADE CATALOGUES

CHAMPION RIVET COMPANY, *Cleveland, O.* Addenda to scientific facts. *1916.*

ELECTRIC STORAGE BATTERY CO., *Philadelphia, Pa.* Bulletin 151. The "Exide," "Hycap-Exide," "Thin-Exide" batteries for industrial trucks and tractors. *Dec. 1915.*

——— 152. The "Exide" batteries for electric pleasure and commercial vehicles. *Nov. 1915.*

FLANNERY BOLT CO., *Pittsburgh, Pa.* Staybolts. *Dec. 1915.*

STEPHENS-ADAMSON MFG. CO., *Aurora, Ill.* Labor Saver. *Dec. 1915.*

TEXAS COMPANY, *New York, N. Y.* Lubrication. *Dec. 1915.*

UNDER-FEED STOKER CO., *Chicago, Ill.* Publicity Magazine. *Dec. 1915, Jan. 1916.*

VALLEY IRON WORKS CO., *Appleton, Wis.* The Beater. *Dec. 1915.*

Walworth Mfg. Co., *Boston, Mass.* Walworth Log. *Dec. 1915.*

Waterloo Cement Machinery Corporation, *Waterloo, Iowa.* Wonder Paver. 7 pp.

Wemlinger Co., Inc., *New York, N. Y.* Wemco specifications for making concrete floors. Report upon "National Frost-proofing."

ADDITIONS BY THE UNITED ENGINEERING SOCIETY

American Scenic & Historic Preservation Society. Twentieth Annual Report, 1915. *Albany, 1915.* Gift of George F. Kunz.

Auskunftsbuch für die Chemische Industrie, H. Blücher. ed. 9. *Leipzig, 1915.*

Bau der Dampfturbinen, Alfred Musil. *Leipzig, 1904.*

Callendar Steam Tables, H. L. Callendar. *New York, 1915.*

Andrew Carnegie. An anniversary address delivered before the Carnegie Institute of Technology, Nov. 24, 1915 by Henry S. Pritchett. *Cleveland, 1915.* Gift of William Howard Brett.

Century of Inventions of the Marquis of Worcester, Charles F. Partington. *London, 1825.*

Die Chemische Industrie, Gustav Müller. *Leipzig, 1909.*

Concrete Stone Manufacture, Harvey Whipple. *Detroit, 1915.*

Copper Deposits of the Eastern Townships of the Province of Quebec. Report. *Quebec, 1915.*

Dartmouth College. Catalogue 1915-16. *Hanover, N. H., 1915.* Gift of Dartmouth College.

Deutschen Buchdrucker-Berufs-Genossenschaft. Geschäfts Bericht 1914. *Frankfurt am Main, 1914.* Gift of Deutschen Buchrucker Berufs-Genossenschaft.

Directory of Directors in the City of New York, 1915-16. *New York, 1915-16.*

District Heating, S. M. Bushnell and F. B. Orr. *New York, 1915.*

Dynamometers, F. J. Jervis-Smith. *New York, 1915.*

Economics of Contracting, D. J. Hauer. Vol. II. *Chicago, 1915.*

Elasticity and Resistance of the Materials of Engineering, Wm. H. Burr. ed. 7. *New York, 1915.*

Electric Elevators, Their Construction and Operation. Elmer G. Henderson. *Chicago, 1915.*

Electroplating, W. R. Barclay and C. H. Hainsworth. *London, 1912.*

Elevators, John H. Jallings. *Chicago, 1915.*

Engineer Field Manual, Parts I-VI. ed. 4. Professional papers of the Corps of Engineers, U. S. Army, no. 29. *Washington, 1912.*

Engineering Index. 1915. *New York, 1915.*

Estimating the Cost of Work, William B. Ferguson. *New York, 1915.*

Factory Power and Costs, Joseph G. Branch. *Chicago, 1914.*

Field Service Regulations, United States Army, 1914. *Washington, 1914.*

Ford Methods and the Ford Shops, H. L. Arnold and F. L. Faurote. *New York, 1915.*

History of Money in America, Alexander Del Mar. *New York, 1899.*

International Acetylene Association. Seventeenth Annual Report. *New York, 1915.* Gift of Association.

International Exposition, St. Louis, 1904. Official Catalogue of the Exhibition of the German Empire. Gift of Edward Caldwell.

International Railroad Master Blacksmiths' Association. Proceedings of the 23d Annual Convention, 1915. Gift of Association.

Iowa. Board of Railroad Commissioners. Thirty-fifth Annual Report, 1912. *Des Moines, 1912.* Gift of Commissioners.

Ironmonger Diary, 1916. *London, 1916.*

Irrigation Practice and Engineering. Vol. II—Conveyance of water, B. Etcheverry. *New York, 1915.*

Jahres Bericht über die Leistungen der Chemischen Technologie für das Jahr 1914, pts. 1-2. *Leipzig, 1915.*

Koninklijk Instituut van Ingenieurs. Jaarboekje. 1916. *'s-Gravenhage, 1916.*

Life of Henry Bell, Edward Morris. *London, 1844.*

Der Luftkrieg, 1914-15. *Leipzig, 1915.* Gift of Leon Goldmerstein.

McGraw Waterworks Directory, 1915. *New York, 1915.*

Mechanical Engineers' Pocket-book. William Kent. ed. 9. *New York, 1915.*

Michigan Engineer. Containing the Proceedings of the Michigan Engineering Society, 1915. *Ann Arbor, 1915.* Gift of Michigan Engineering Society.

Micrometers, Slide Gauges and Calipers, Their Constructions and Use, A. W. Marshall and Geo. Gentry. ed. 2. *London.*

Military Railways, Major W. D. Connor. Professional Papers, no. 32, Corps of Engineers, U. S. Army. *Washington, 1910.*

Die Moderne Vorkalkulation in Maschinenfabriken, M. Siegerist und M. F. Bork. *Berlin, 1915.*

Moody's Manual. Complete list of securities maturing Jan. 1, 1916-Dec. 31, 1917. Arranged chronologically. Vol. I. *New York, 1915.* Gift of Moody Manual Co.

Motoren. Göpel und Windmotoren, Wasserräder und Turbinen, Verbrennungsmotoren. Uhland's Handbuch für den praktischen Maschinenkonstrukteur, V. Band. *Berlin.*

Motorluftschiff Studiengesellschaft M. B. H. Jahrbuch 1908-10. *Berlin.*

Müllerei und Mühlenbau, Friedrich Kettenbach. Vols. 1-2. *Leipzig.*

National Highways Association. Literature and maps of the Association. 1915. Gift of Association.

New Geographical Survey of the United States and the World, Based on the Latest Official Data. *New York, 1915.*

New Jersey Interstate Bridge Commission. Report, 1st-4th. 1909-1913. *Union Hill, 1913.* Gift of New Jersey Interstate Bridge & Tunnel Commission.

——— Zone Map Showing Counties, Cities and Towns within the Metropolitan District of New York. Gift of New Jersey Interstate Bridge & Tunnel Commission.

New York Interstate Bridge Commission. 2d-6th. Report. 1909-1914. *Albany, 1909-14.* Gift of New York State Bridge & Tunnel Commission.

Der Oelmotor. I. Jahrgang, 1912-13. *Wien, 1913.*

Practical Electro-plating, W. L. D. Bedell. ed. 3. *1912.*

Problems Pertaining to Steel Tubes When Used as Liquid Conductors. A treatise by O. G. Wellton. Part I. *Lund, 1915.*

Public Utilities Reports, Annotated. 1915, E. *Rochester, 1915.*

Reminiscences of Captain James B. Eads of Jetties Fame, Edmond Souchon. Read before Louisiana Historical Society, May 19, 1915. Gift of Wm. Beer.

Rockefeller Foundation. Annual Report, 1913-14. *New York.* Gift of Rockefeller Foundation.

Specifications Covering the Construction at Crossings of Overhead Lines of Public Utilities. Prepared by a Joint Committee representing the different classes of utilities in interest and recommended to The Public Service Commission of the Commonwealth of Pennsylvania for adoption. *Philadelphia, 1915.* Gift of Paul Spencer.

Standard Specifications for Hydrated Lime Adopted in 1915 by the American Society for Testing Materials, "Pamphlet H," October, 1915. Gift of National Lime Manufacturers' Association, Hydrated Lime Bureau.

Steel Construction, Henry J. Burt. *Chicago, 1914.*

Smoke Abatement and Electrification of Railway Terminals in Chicago. Report of the Chicago Association of Commerce Committee of Investigation on Smoke Abatement and Electrification of Railway Terminals. *Chicago, 1915.* Gift of Chicago Association of Commerce.

Technique of Modern Tactics, P. S. Bond and M. J. McDonough. ed. 2. *Menasha, 1915.*

Telephone Appraisal Practice, J. C. Slippy. *Pittsburgh, 1915.*

Thayer School of Civil Engineering. Dartmouth College. Annual for 1915. *Hanover, N. H., 1915.* Gift of Dartmouth College.

Theoretical Elements of Electrical Engineering, C. P. Steinmetz. ed. 4. *New York, 1915.*

Theory of Structures, Charles M. Spofford, ed. 2. *New York, 1915.*

Thomas' Register of American Manufacturers. ed. 7. 1915. *New York, 1915.*

Tramway Track Construction and Maintenance, R. B. Holt. *London, 1915.*

Treatise on the Theory of Alternating Currents, A. Russell, vol. I. ed. 2. *Cambridge, 1914.*

Van Nostrand's Monthly Record of Scientific Literature. Vols. 7-9; 16-21; 25-30; 31, nos. 1, 3, 6-7, 9, 11; 32, no. 9, 10, 12. *New York, 1878-81; 1887-93; 1897-1911.* Gift of Edward Caldwell.

Ventilation for Dwellings, Rural Schools and Stables, F. H. King. *Madison, Wis., 1908.*

Watch and Clock Makers' Handbook, F. J. Britten. ed. 11. *London-New York, 1915.*

Waterproofing Concrete with Hydrated Lime. "Pamphlet F." 1915. Gift of National Lime Manufacturers Association, Hydrated Lime Bureau.

Welding and Cutting Metals by the Oxyacetylene Process, a text book. *Minneapolis.*

Wireless Time Signals. Issued by the Paris Bureau of Longitudes. *London-New York, 1915.*

GIFT OF NATIONAL CHILD LABOR COMMITTEE

Annual Conference (10th). Federal Child Labor Bill. Child Labor Bulletin, Feb. 1914.

Child Labor and the Republic. Proceedings of the 3d Annual Meeting. *New York, 1907.*

Child Workers of the Nation. Proceedings of 5th Annual Conference. *New York, 1909.*

Clinker and Some Other Children. *1914.*

GIFT OF ERNEST L. JONES

Aero, v. 1, no. 1-2, 4-19, 21-32, *1909;* v. 2, nos. 33-43, 45-54, 56-57, *1910;* v. 3, nos. 61, 67-68, 70, 73-77, 79, 83-84, *1910;* v. 4, nos. 85-89, 91-93, 95-96, *1911;* v. 5, nos. 97-105, *1911;* v. 6, nos. 106-117, *1912;* v. 7, nos. 118-122, *1913.*

Aeronautical journal, v. 11, nos. 41, 43-44, *1907;* v. 12, nos. 45, 47-48, *1908;* v. 13, nos. 51-52, *1909;* v. 14, nos. 53-56, *1910;* v. 15, nos. 57-60, *1911;* v. 16, nos. 61-64, *1912;* v. 17, nos. 66-68, *1913;* v. 18, nos. 69, 71-72, *1914;* v. 19, no. 74, *1915.*

Aeroplane, v. 2, nos. 35-44, 46-54, 56, *1912;* v. 3, nos. 2-4, 6-7, 10-11, 13-23, 25-26, *1912;* v. 4, nos. 1-7, 9-26; *1913;* v. 5, nos. 1-2, 4-9, 11-16, 18-22, 24-26, *1913;* v. 6, nos. 1, 3-6, 8-12, 14-22, 24-26, *1914;* v. 7, nos. 1-10, 12, 15-17, 19, 23-26, *1914;* v. 8, nos. 4-5, *1915.*

Aircraft, v. 5, no. 11, *1915.*

Automobilia, Jan., May-Dec., *1908;* Jan., Mar., May, Oct.-Dec., *1909.*

Avia, nos. 5-6, 8-9, 11-17, *1913;* nos. 1-8, 11-15, *1914.*

Deutsche zeitschrift für Luftschiffahrt, v. 14, nos. 1-26, *1910;* v. 15, nos. 1-6, 8-17, 19-26, *1911.*

Deutsche Luftfahrer zeitschrift, v. 16, nos. 1-2, 4-6, 8-22, 24-25, *1912;* v. 17, nos. 1-8, 10-20, 22-26, *1913;* v. 18, nos. 1-6, 8-15, *1914.*

Encyclopédie de l'aviation, v. 1, nos. 1-9, *1909;* v. 2, nos. 10-19, *1910;* v. 3, nos. 20-24, *1911.*

Flight, new series, v. 1, nos. 1-14, 16-35, 38-52, *1909;* v. 2, nos. 53-65, 67-79, 81, 84, 87-88, 90, 93-105, *1910;* v. 3, nos. 106-137, 139-154, 156-157, *1911;* v. 4, nos. 158, 160-171, 173-183, 185-195, 197, 207, 209, *1912;* v. 5, nos. 210-214, 217-261, *1913;* v. 6, nos. 262-290, 300, 304-311, 313, *1914;* v. 7, nos. 314-329, 331-334, 336-352, *1915.*

Flug-u. Motor-technik, v. 3, nos. 20-32, *1909;* v. 4, nos. 1-7, 9-24, *1910.*

Flugsport, v, 1, nos. 14-22, 24-26, *1909;* v. 2, nos. 1-7, 9-20, 22-24, *1910;* v. 3, nos. 1-9, 11-27, *1911;* v. 4, nos. 1-15, 17-24, 26, *1912;* v. 5, nos. 1-4, 6-26, *1913;* v. 6, nos. 1-6, 9-26, *1914;* v. 7, nos. 2-11, 13-18, *1915.*

Illustrierte aeronautische mitteilungen, v. 10, no. 12, *1906;* v. 11, nos. 5, 7-12, *1907;* v. 12, nos. 1-8, 12-26, *1908;* v. 13, nos. 1, 3-15, 17-26, *1909.*

L'aéro-mécanique, v. 1, nos. 1-6, 8-11, *1908;* v. 2, nos. 1-10, *1909;* v. 3, nos. 1-2, 5-9; *1910;* v. 4, nos. 1-5, 7, 10, 12, *1911;* v. 5, no. 3, *1912.*

L'Aero-revue, v. 1, nos. 6-12, *1907;* v. 2, nos. 1-6, *1908.*

L'aeronautique, v. 6, nos. 22-24, *1907;* v. 7, nos. 25-26, 28-29, *1908;* v. 9, no. 1, *1911;* v. 10, nos. 4-5, *1912.*

L'Aerophile, v. 13, nos. 3, *1905;* v. 14, no. 5, *1906;* v. 15, nos. 8, 12, *1907;* v. 16, nos. 1-2, 4-24, *1908;* v. 17, nos. 1-16, 18, 20-24, *1909;* v. 18 and v. 19 complete, *1911,* v. 20, nos. 1-11, 13-17, 19-24, *1912;* v. 21, nos. 1-2, 4-8, 10-12, *1913;* v. 22, nos. 3, 11, 13-15, *1914;* v. 23, nos. 7-8, 11-14, *1915.*

L'Aérostation, v. 4, nos. 10-12, *1907;* v. 5, nos. 15-17, *1908;* v. 6, nos. 18, 20-21, *1909;* v. 7, nos. 22-25, *1910;* v. 8, nos. 26-27, 29, *1911;* v. 9, nos. 30-34, *1912;* v. 10, nos. 35-37, *1913;* v. 11, nos. 38-39, *1914.*

L'Aviation illustrée, v. 1, nos. 6-18, 20-37, *1909;* v. 2, nos. 38-41, 43-52, 56, 58, 61-64, *1910.*

La Conquête de l'Air, v. 10, nos. 2, 4-21, 23-24, *1913;* v. 11, nos. 1-14, *1914.*

La Ligue Nationale Aérienne, v. 1, nos. 1-2, 4-10, *1909.*

La revue aérienne, v. 3, nos. 30-52, *1910;* v. 4, nos. 54-76, *1911;* v. 5, nos. 78-100; *1912;* v. 6, nos. 102-114, *1913;* v. 7, nos. 138-139, *1914.*

La revue aéronautique et automobile, v. 2, nos. 14-15, *1913;* v. 3, nos. 4-13, *1914.*

La Revue de l'Aviation, v. 2, nos. 5-11, 13, *1907;* v. 3, nos. 17-18, 20-25, *1909;* v. 4, nos. 26-36, 38-47, *1910.*

La technique aéronautique, v. 5, nos. 38-48, *1911;* v. 6, nos. 49-63, 65-68, 70-71, *1912;* v. 7, nos. 73-84, *1913;* v. 8, nos. 86-94, 96, *1913;* v. 9, nos. 97-108, *1914;* v. 10, nos. 109-112, *1914.*

De Luchtvaart, v. 4, nos. 13, 19-24, 26, *1912;* v. 5, nos. 1-7, 9-11, *1913.*

Die Luftflotte, v. 3, nos, 4-7, *1911;* v. 4, nos. 1-12, *1912;* v. 5, nos. 1-4, 7-11, *1913;* v. 6, nos. 1-12, *1914.*

Mitteleuropäischen Motorwagen-Verein Zeitschrift, v. 10, nos. 1, 8, 11, *1911;* v. 11, no. 8, *1912.*

Osterreichnische flug-zeitschrift, v. 5, nos. 1-17, 19, 21-24, *1911;* v. 6, nos. 1-22, 24, *1912;* v. 7, nos. 1-16, 18-21, 23-24, *1913;* v. 8, nos. 1-9, 11-15, 17, 24, *1914;* v. 9, nos. 5-8, 13-16, *1915.*

Rendiconti degli studi ed esperienze, v. 1, no 1, *1911;* v. 2, nos. 2-4, *1912;* v. 3, nos. 7-8, *1913;* v. 4, nos. 10-12, *1914.*

Répertoire de l'Aéronautique, nos. 1-4, *1911;* nos. 5-8, 10-13, *1912;* nos. 15-23, *1913;* nos. 24-27, *1914.*

Revista de locomocion aérea, v. 1, nos. 2, 4-5, *1909.*

Revue juridique internationale de la locomotion aérienne, v. 2, nos. 1-8, 10-12, *1911;* v. 3, complete, *1912;* v. 4, nos. 1-10, 12, *1913;* v. 5, nos. 1-5, *1914.*

Rivista tecnica di aeronautica, v. 6, nos. 1-6, 8-12, *1909;* v. 7, nos. 1-12, *1910;* v. 8, nos. 1-3, *1911;* v. 10, nos. 1-2, *1915.*

Schweizer. Aero Klub, Bulletin, v. 1, nos. 1, 5-6, *1907;* v. 2, complete, *1908;* v. 3, nos. 1-3, 6, *1909;* v. 4, complete, *1910;* v. 5, complete, *1911;* v. 6, complete, *1912;* v. 7, nos. 1-11, *1913;* v. 8, complete, *1914;* v. 9, nos. 1-9, *1915.*

Societa Aeronautica Italiana, Bolletino, v. 4, complete, *1907;* v. 5, complete, *1908.*

Technika Bosduchoglabania, nos. 1-9, *1912;* nos. 1-6, *1913.*

Wiener Luftschiffer-zeitung, v. 6, nos. 7-12, *1907;* v. 7, nos. 1-5, 7-12, *1908;* v. 8, complete, *1909;* v. 9, nos. 1-4, 6-24, *1910;* v. 10, nos. 1-15, 17-24, *1911;* v. 11, nos. 1-22, 24, *1912;* v. 12, nos. 1-19, 20-24, *1913;* v. 13, nos. 1, 3-10, 13-15, *1914.*

Zeitschrift für Flugtechnik und Motorluftschiffahrt, v. 1, nos. 1-2, 5, 17-21, 23, *1910;* v. 2, nos. 1-6, 8-24, *1911;* v. 3, nos. 1-22, 24, *1912;* v. 5, no. 2, *1914.*

OFFICERS AND COUNCIL

1916

President

D. S. Jacobus

Vice-Presidents

Terms expire December 1916

George W. Dickie
Henry Hess
James E. Sague

Terms expire December 1917

Wm. B. Jackson
J. Sellers Bancroft
Julian Kennedy

Managers

Terms expire December 1916

Arthur M. Greene, Jr.
John Hunter
Elliott H. Whitlock

Terms expire December 1917

Charles T. Main
Spencer Miller
Max Toltz

Terms expire December 1918

John H. Barr
H. de B. Parsons
John A. Stevens

Past-Presidents

Members of the Council for 1916

Jesse M. Smith
Alex. C. Humphreys
John A. Brashear
W. F. M. Goss
James Hartness

Chairman of Finance Committee

Robert M. Dixon

Treasurer

William H. Wiley

Honorary Secretary

Frederick R. Hutton

Secretary

Calvin W. Rice

Executive Committee of the Council

D. S. Jacobus, *Chairman*
John H. Barr
Arthur M. Greene, Jr.
Henry Hess
Spencer Miller
James E. Sague

STANDING COMMITTEES

Finance

Robert M. Dixon (2), *Chairman;* W. D. Sargent (1), W. H. Marshall (3), Alfred E. Forstall (4), George M. Forrest (5)

Meetings

H. L. Gantt (1), *Chairman;* Robert H. Fernald (2), John H. Barr (3), Leon P. Alford (4), Dexter S. Kimball (5)

Publication

Irving E. Moultrop (1), Fred. R. Low (2), Fred J. Miller (3), Henry Hess (4), C. I. Earll (5)

Membership

Henry C. Meyer, Jr. (1), L. R. Pomeroy (2), Hosea Webster (3), Charles E. Lucke (4), Fred J. Miller (5)

Library

Leonard Waldo (1), John W. Lieb (2), Jesse M. Smith (3), Walter M. McFarland (4), The Secretary

House

William N. Dickinson (1), Frederick A. Scheffler (2), James W. Nelson (3), Orrie P. Cummings (4), Maxwell M. Upson (5)

Research

Richard H. Rice (1), Ralph D. Mershon (2), R. J. S. Pigott (3), Arthur M. Greene, Jr. (4), Carl C. Thomas (5)

Public Relations

Worcester R. Warner (1), George M. Brill (2), Morris L. Cooke (3), Spencer Miller (4), One to be appointed

Constitution and By-Laws

Jesse M. Smith (1), *Chairman;* Frederick R. Hutton (2), *Vice-Chairman;* James E. Sague (3), Geo. M. Basford (4), Ira N. Hollis (5)

Standardization

Henry Hess (1), John H. Barr (2), Charles Day (3), Carl Schwartz (4), Wm. F. Kiesel, Jr. (5)

Note—Numbers in parentheses indicate number of years the member has yet to serve.

SOCIETY REPRESENTATIVES

American Association Advancement of Science
Alex. C. Humphreys, Wm. B. Jackson

American Society for Testing Materials
Joint Conference Committee
Charles W. Baker, Arthur M. Greene, Jr.

American Society for Testing Materials
Modification Briggs Standard for Pipe Threads
Stanley G. Flagg, Jr., John C. Bannister

Classification of Technical Literature
Fred. R. Low, *Chairman;* William W. Bird, L. P. Breckenridge, Alfred E. Forstall, Edwin J. Prindle

Conference Committee on Electrical Engineering Standards
Henry G. Stott, *Chairman;* Albert F. Ganz, Carl Schwartz

Conference Committee of National Engineering Societies
Charles W. Baker, Arthur M. Greene, Jr.

Conservation
George F. Swain, *Chairman;* Charles W. Baker, Luther D. Burlingame, M. L. Holman, Calvin W. Rice

Constitutional Convention
Charles W. Baker, *Chairman;* E. G. Spilsbury, Arthur M. Greene, Jr.

Engineer Reserve Corps
William H. Wiley, *Chairman;* John A. Hill, *Vice-Chairman;* W. F. M. Goss, H. A. Gillis, Alex. C. Humphreys

Engineering Foundation
W. F. M. Goss, Alex. C. Humphreys

Expert Testimony Committee
Francis H. Richards, *Chairman;* Wm. H. Boehm, H. de B. Parsons

John Fritz Medal
John R. Freeman (1), Ambrose Swasey (2), John A. Brashear (3), Frederick R. Hutton (4)

Naval Consulting Board of the United States
W. L. R. Emmet, Spencer Miller

Standardization of Pipe and Pipe Fittings for Fire Protection
Chas. A. Olson

Trustees United Engineering Society
Alex. C. Humphreys (1), John R. Freeman (2), Henry G. Stott (3)

SPECIAL COMMITTEES

Administration
Robert M. Dixon, *Chairman;* Leon P. Alford, Geo. M. Basford, Geo. M. Forrest, Jos. W. Roe

Am. Soc. M. E. Junior Prizes
Robert H. Fernald, *Chairman;* Fred. E. Rogers, George B. Brand

Am. Soc. M. E. Student Prizes
Frederick R. Hutton, *Chairman;* Robert H. Fernald, Dexter S. Kimball

Boiler Code Committee
John A. Stevens, *Chairman;* C. W. Obert, *Secretary;* Wm. H. Boehm, Rolla C. Carpenter, Frank H. Clark, Francis W. Dean, Thomas E. Durban, Carl Ferrari, Elbert Curtiss Fisher, Chas. E. Gorton, Arthur M. Greene, Jr., Richard Hammond, A. L. Humphrey, Chas. L. Huston, D. S. Jacobus, S. F. Jeter, Wm. F. Kiesel, Jr., W. F. MacGregor, Edward F. Miller, M. F. Moore, Irving E. Moultrop, Richard D. Reed, Henry G. Stott, H. H. Vaughan

Depreciation and Obsolescence
Alex. C. Humphreys, *Chairman;* J. G. Bergquist, Charles J. Davidson, Alfred E. Forstall, F. W. Kelley, H. Struckmann

Engineering Education
Alex. C. Humphreys, Frank H. Clark

Filter Standardization
George W. Fuller, *Chairman;* Jas. C. Boyd, Philip N. Engel, Wm. Schwanhausser

Flanges for Hydraulic Work
Henry G. Stott, *Chairman;* A. R. Baylis, Arthur M. Houser, Julian Kennedy, E. A. Stillman, W. M. White

Increase of Membership
Irving E. Moultrop, *Chairman;* Fred H. Colvin, James V. V. Colwell, Robert M. Dixon, Wm. R. Dunn, Leigh A. Hunt, John P. Ilsley, Edwin B. Katte, Richard B. Sheridan

Chairmen of Sub-Committes on Increase of Membership
Atlanta, Park A. Dallis; *Boston,* A. L. Williston; *Buffalo,* W. H. Carrier; *Chicago,* Philip N. Engel; *Cincinnati,* John T. Faig; *Cleveland,* R. B. Sheridan; *Los Angeles,* O. J. Root; *Michigan,* H. H. Esselstyn; *Milwaukee,* Fred. H. Dorner; *Minnesota,* Max Toltz; *New Haven,* E. H. Lockwood; *New York,* J. A. Kinkead; *Philadelphia,* T. C. McBride; *Rochester,* John C. Parker; *St. Louis,* John Hunter; *San Francisco,* Wynn Meredith; *Seattle,* Robert M. Dyer; *Troy,* Albert E. Cluett; *Worcester,* Edgar H. Reed

Joint Committee on Standards for Graphic Presentation
Willard C. Brinton, *Chairman;* Leonard P. Ayres, N. A. Carle, Robert E. Chaddock, F. A. Cleveland, C. B. Davenport, Roland P. Falkner, W. S. Gifford, J. Arthur Harris, H. E. Hawkes, J. A. Hill, H. D. Hubbard, Robert H. Montgomery, Alex. Smith, Judd Stewart, Wendell M. Strong, Edward L. Thorndike

Local Sections
Elliott H. Whitlock, *Chairman;* W. F. M. Goss, Louis C. Marburg, Walter Rautenstrauch, D. Robert Yarnall

National Museum
G. F. Kunz, George Mesta, H. G. Reist, Ambrose Swasey

Patent Laws
Wm. H. Blauvelt, Carl C. Thomas, Edward Weston, W. E. Winship, Benjamin F. Wood

Pipe Threads International Standard
Edwin M. Herr, *Chairman;* Wm. J. Baldwin, Geo. M. Bond, Stanley G. Flagg, Jr., L. V. Benet, *Paris Representative*

Power Tests
Geo. H. Barrus, *Chairman;* E. T. Adams, L. P. Breckenridge, D. S. Jacobus, William Kent, Edward F. Miller, Arthur West, Arthur C. Wood

Refrigeration
D. S. Jacobus, *Chairman;* P. DeC. Ball, Edward F. Miller, Gardner T. Voorhees

SPECIAL COMMITTEES—*Continued*

Research Committee, Sub-Committee on Fuel Oil
Raymond H. Danforth, *Chairman;* Lee E. Barrows, Andrew M. Hunt

Research Committee, Sub-Committee on Investigation of the Clinkering of Coal
Lionel S. Marks, *Chairman;* F. C. Hubley, A. V. Bleininger, O. W. Palmenberg, S. W. Parr

Research Committee, Sub-Committee on Lubrication
Albert Kingsbury, *Chairman;* A. E. Flower, Mayo D. Hersey, George B. Upton

Research Committee, Sub-Committee on Machine Tools
Leon P. Alford, *Chairman;* A. L. DeLeeuw, E. E. Barney

Research Committee, Sub-Committee on Materials of Electrical Engineering
R. D. Mershon

Research Committee, Sub-Committee on Safety Valves
Edward F. Miller, *Chairman;* Philip G. Darling, Henry D. Gordon, Frederick L. Pryor, Frederic M. Whyte

Research Committee, Sub-Committee on Steam Meters
R. J. S. Pigott, *Chairman.* (Other members to be appointed)

Research Committee, Sub-Committee on Worm Gearing
Fred. A. Halsey, *Chairman.* (Other members to be appointed)

Spring Meeting
William B. Gregory, *Chairman;* Henry L. Hutson, *Secretary*

Student Branches
Frederick R. Hutton, *Chairman;* George M. Brill, William Kent, George A. Orrok

Tellers of Election
Robert H. Kirk, *Chairman;* Erwin S. Cooley, Harry A. Hey

Tolerances in Screw Thread Fits
Luther D. Burlingame, *Chairman;* Ellwood Burdsall, Frederic G. Coburn, Fred H. Colvin, A. A. Fuller, James Hartness, W. R. Porter, Frank O. Wells, Walter F. Worthington, Chas. D. Young

SUB-COMMITTEES OF THE COMMITTEE ON MEETINGS

Air Machinery
Carl C. Thomas, *Chairman;* B. C. Batchelder, Hugh V. Conrad, Fred. A. Halsey, O. P. Hood, Frederick W. O'Neil, William Prellwitz, Richard H. Rice

Cement Manufacture
H. J. Seaman, *Chairman;* G. S. Brown, *Vice-Chairman;* J. G. Bergquist, W. R. Dunn, F. W. Kelley, Morris Kind, F. H. Lewis, W. H. Mason, R. K. Meade, Ejnar Posselt, H. Struckmann, A. C. Tagge, P. H. Wilson

Fire Protection
John R. Freeman, *Chairman;* Edward V. French, *Vice-Chairman;* Albert Blauvelt, F. M. Griswold, H. F. J. Porter, T. W. Ransom, Ira H. Woolson

Gas Power
H. J. Freyn, *Chairman;* George F. Gebhardt, *Secretary;* Charles J. Bacon, C. H. Benjamin, Alfred D. Blake, W. D. Ennis, Frederick R. Hutton, Wm. T. Magruder, J. M. Spitzglass, H. H. Suplee

Hoisting and Conveying
C. K. Baldwin, Alex. C. Brown, Orton G. Dale, P. J. Fickinger, Frank E. Hulett, Spencer Miller, A. L. Roberts, Harry Sawyer, Richard B. Sheridan

Industrial Buildings
F. A. Waldron, *Chairman;* Harry A. Burnham, Charles Day, William Dalton, J. O. DeWolf, Charles T. Main

Machine Shop Practice
H. K. Hathaway, *Chairman;* H. P. Fairfield, *Secretary;* L. D. Burlingame, E. P. Bullard, Jr., Fred H. Colvin, A. L. DeLeeuw, W. H. Diefendorf, F. L. Eberhardt, R. E. Flanders, A. A. Fuller, E. J. Kearney, Wm. Lodge, H. M. Lucas, F. E. Rogers, N. E. Zusi

Protection of Industrial Workers
John H. Barr, *Chairman;* Melville W. Mix, John P. Jackson, John W. Upp, William A. Viall

Railroads
Edwin B. Katte, *Chairman;* Geo. M. Basford, W. G. Besler, Frank H. Clark, C. E. Eveleth, W. F. M. Goss, A. L. Humphrey, Wm. F. Kiesel, Jr., Norman W. Storer, H. H. Vaughan, Royden V. Wright

Textiles
Charles T. Plunkett, *Chairman;* Edward W. Thomas, *Secretary;* E. M. Bates, Albert G. Duncan, E. D. France, Edwin F. Greene, Franklin W. Hobbs, W. E. Hooper, C. R. Makepeace, Charles H. Manning

LOCAL SECTIONS OF THE SOCIETY

Atlanta
Earl F. Scott, *Chairman;* Park A. Dallis, *Secretary;* Oscar Elsas, Frank H. Neely, L. W. Robert, Jr.

Birmingham
Roy E. Brakeman, *Chairman;* Paul Wright, *Secy-Treas.*

Boston
H. N. Dawes, *Chairman;* W. G. Snow, *Secretary;* C. H. Fish, A. L. Williston, C. W. E. Clarke

Buffalo
David Bell, *Chairman;* C. H. Bierbaum, C. A. Booth, S. B. Daugherty, Jas. W. Gibney

Chicago
H. M. Montgomery, *Chairman;* Joseph Harrington, *Vice-Chairman;* Robert E. Thayer, *Secretary;* Harry T. Bentley, Charles E. Wilson

Cincinnati
J. B. Stanwood, *Chairman;* John T. Faig, *Secretary;* W. G. Franz, G. W. Galbraith, George Langen

Los Angeles
W. W. Smith, *Chairman;* William A. E. Noble, *Vice-Chairman;* Ford W. Harris, *Secretary;* Frededick C. Finkle, O. J. Root

LOCAL SECTIONS—*Continued*

Milwaukee

Louis E. Strothman, *Chairman;* Fred H. Dorner, *Secretary;* M. A. Beck, Walter C. Lindemann, R. H. Robinson, Arthur Simon, Henry Weickel

Minnesota

Charles W. Tubby, *Chairman;* John V. Martenis, *Vice-Chairman;* Quincy A. Hall, *Secy-Treas.;* Wm. H. Kavanaugh, Max Toltz

New Haven

H. B. Sargent, *Chairman;* E. H. Lockwood, *Secretary;* L. P. Breckenridge, Henry Brewer, J. A. Norcross

New York

H. R. Cobleigh (1), *Chairman;* John P. Neff (2), *Secretary;* J. J. Swan (3), Edwin J. Prindle (4), Alfred D. Blake (5)

Philadelphia

Robert H. Fernald, *Chairman;* William R. Jones, *Secretary;* Emmett B. Carter, Henry E. Ehlers, James E. Gibson, Andrew C. Vauclain

St. Louis

Edward Flad, *Chairman;* Geo. R. Wadleigh, *Secretary;* Frederick E. Bausch, Edwards R. Fish, Ernest L. Ohle

San Francisco

Frederick W. Gay, *Chairman;* Frank H. Varney, *Vice-Chairman;* C. F. Braun, *Secretary;* H. L. Terwilliger, J. T. Whittlesey

Worcester

Paul B. Morgan, *Chairman;* Edgar H. Reed, *Secretary;* Carl F. Dietz, Howard P. Fairfield, Frederick W. Parks

OFFICERS OF AFFILIATED SOCIETY

Providence Association of Mechanical Engineers

W. H. Paine, *President;* Arthur H. Annan, *Vice-President;* J. A. Brooks, *Secretary;* A. H. Whatle., *Treasurer*

OFFICERS OF THE STUDENT BRANCHES

INSTITUTION	DATE AUTHORIZED BY COUNCIL	HONORARY CHAIRMAN	CHAIRMAN AND SECRETARY
Arkansas, University of, Fayetteville, Ark.	1910	B. N. Wilson	W. G. Horton J. C. Moody
Armour Institute of Tech., Chicago, Ill.	1909	G. F. Gebhardt	J. M. Byanskas E. S. Echlin
Bucknell College, Lewisburg, Pa.	1916	F. E. Burpee	T. L. James C. E. Lewis
California, University of, Berkeley, Cal.	1912	Joseph N. LeConte	C. Sebastian E. Eichler
Carnegie Institute of Tech., Pittsburgh, Pa.	1913	W. Trinks	Benj. Schwartz John T. Eaton
Case School of Applied Science, Cleveland, O.	1913	F. H. Vose	Geo. S. Baldwin Louis H. Ashmun
Cincinnati, University of, Cincinnati, O.	1909	J. T. Faig	A. J. Langhammer W. T. Cowell
(Colo.) State Agri. College, Fort Collins, Colo.	1914	J. W. Lawrence	A. T. Johnson T. H. Sackett
Colorado, University of, Boulder, Colo.	1914	John A. Hunter	Edison B. Good Wilfred Sawyer
Columbia University, New York, N. Y.	1909	Chas. E. Lucke	L. H. Nielsen Chas. W. Sengstaken
Cornell University, Ithaca, N. Y.	1908	R. C. Carpenter	A. R. Cota W. F. Courtney
Georgia School of Tech., Atlanta, Ga.	1915	J. S. Coon	R.S. Fleet P. N. Johnson
Illinois, University of, Urbana, Ill.	1909	W. F. M. Goss	R. C. Maley E. B. Stout
Iowa, State University of, Iowa City, Ia.	1913	R. S. Wilbur	C. W. Harrison Victor Johnson

Kansas State Agri. College, Manhattan, Kan.	1914	A. A. Potter	L. A. Wilsey F. R. Rawson
Kansas, University of, Lawrence, Kan.	1909	A. H. Sluss	J. Stillwell A. J. Nigg
Kentucky, State University of, Lexington, Ky.	1911	F. P. Anderson	J. D. Garrett Geo. L. Cherry
Lehigh University, South Bethlehem, Pa.	1911	P. B. de Schweinitz	Miles W. Kresge Wm. C. Hartmann
Leland Stanford Jr. University, Stanford University, Cal.	1909	W. F. Durand	W. H. Warren H. F. Elliot
Louisiana State University, Baton Rouge, La.	1916	E. W. Kerr	
Maine, University of, Orono, Me.	1910	C. H. Lekberg	J. M. Dodge A. G. Smith
Massachusetts Institute of Tech., Boston, Mass.	1909	E. F. Miller	K. C. Richmond H. P. Gray
Michigan, University of, Ann Arbor, Mich.	1914	John R. Allen	H. S. Manwaring Frank C. Riecks
Minnesota, University of, Minneapolis, Minn.	1913	W. H. Kavanaugh	G. A. Ek I. L. Johnson
Missouri, University of, Columbia, Mo.	1909	H. Wade Hibbard	J. C. Squires R. Coatsworth
Nebraska, University of, Lincoln, Neb.	1909	J. D. Hoffman	L. L. Westling R. B. Saxon
New York University, New York, N. Y.	1909	C. E. Houghton	C. A. Pines John A. Inwright
Ohio State University, Columbus, O.	1911	Wm. T. Magruder	Harold H. Brooks Ray Ellis
Pennsylvania State College, State College, Pa.	1909	Hugo Diemer	G. Jeffery G. S. West
Polytechnic Institute of Brooklyn, Brooklyn, N. Y.	1909	W. D. Ennis	Herman Brandt Charles E. Rohmann
Purdue University, Lafayette, Ind.	1909	G. A. Young	W. T. Miller L. C. McAnley
Rensselaer Polytechnic Institute, Troy, N. Y.	1910	A. M. Greene, Jr.	J. B. Lincoln J. W. Hartman
Stevens Institute of Tech., Hoboken, N. J.	1908	Alex. C. Humphreys	J. B. Roberts, Jr. J. M. Wilcox
Syracuse University, Syracuse, N. Y.	1911	W. E. Ninde	D. R. Hay H. B. Tracy
Throop College of Technology, Pasadena, Cal.	1914	W. H. Adams	R. O. Catland H. A. Black
Virginia Poly. Inst., Blacksburg, Va.	1915	L. S. Randolph	J. W. Kavanaugh G. E. Parker
Washington University, St. Louis, Mo.	1911	E. L. Ohle	John J. Summersby Edmond Siroky
Wisconsin, University of, Madison, Wis.	1909	J. G. D. Mack	J. B. Wilkinson G. C. Richardson
Worcester Polytechnic Inst., Worcester, Mass.	1914	W. W. Bird	Harold Nutt H. P. Fairfield
Yale University, New Haven, Conn.	1910	L. P. Breckenridge	E. B. Ripley W. B. Day

ENGINEERING SURVEY

AT the beginning of the present war there used to occur considerable delays in the delivery of foreign periodicals to the library of the Engineering Societies, due, as explained at the time, partly to the disorganization of the ocean mail service and partly to irregularities in the issue of periodicals themselves. Then for a time foreign periodicals, not excepting German and Austrian ones, used to come with a fair regularity. Of late, however, there has begun to occur again great delays, so that some of the important periodicals, especially from the Central Empires, practically stopped coming. Attention is called to this fact to explain the comparatively small number of articles reported from periodicals in the German language.

SUBJECTS OF ARTICLES

Utilization of Exhaust Heat from Diesel Engines in Turbines.
Brass Cartridges for 18 Pdr. Shells.
Brass Cartridge Cases.
Die-Pressed Castings.
Herringbone Gear Hobbing Machine.
Tools and Devices for Shell Making.
Cutting-off Machine for Shell Work.
Expanding Chuck.
Waving and Band Cutting Fixture.
Nosing Presses.
Mechanical Plug Wrench.
Painting Machine.
Recrystallization of Cold Worked Brass.
Rusting of Iron and Steel.
Bending of a Shaft with Two Bearings.
Lubrication of Bearings and Cylinders.
Equations of Plotted Curves.
Helical Springs Under Centrifugal Action.
Gas-Water Turbine.
Farm Engines.
Geared Turbine.
Power Constant of Gears.
High Pressure Exhaust Steam.
Leaks in Surface Condensers.
Pipe Couplings.
Permutit Water Softening.
Packing Metal Shavings.
Smoke and Railway Electrification in Chicago.

This Month's Articles

An illustrated abstract of an article on the utilization of exhaust heat from internal combustion engines is given, of interest because it refers to methods of utilizing this exhaust heat in prime movers.

In the section Machine Shop Processes is given an abstract on an article on the production of die-pressed castings. Other abstracts refer to the manufacture of brass cartridge cases.

The Machine Tool section deals mainly with machinery for shell manufacture, a subject to which particular attention is paid in Canadian trade papers. Two abstracts of properties of materials are given. One on the recrystallization of cold worked brass on annealing, of particular interest because of the insight which the experiments described give on these variations in the structural constitution of brass. The article on the rusting of iron and steel describes interesting experiments which may help to make clear the still uncertain processes which take place when iron and its alloys "rust."

In the section Mechanics are reported several articles to which particular attention is called. F. L. Fairbanks, in a paper on the lubrication of bearings and cylinders, discusses some of his experiences in the design of bearings, cylinders, and pistons, expressing rather novel views on what actually occurs between two surfaces in friction with one another supposedly protected by a film of oil. A mathematical article on the bending of a shaft having two bearings is reported from a French paper, while in another article is discussed the problem of the centrifugal action as it affects helical springs.

In the section on Power Generation and Transmission is reported a suggestion made by Dugald Clerk concerning a turbine driven by gas through a hydraulic medium, and the question of comparative costs of compressed air and electricity in mine stop haulages is discussed, as well as that of the comparative merits of geared turbine and turbo-electric means for marine propulsion. In the last of these abstracts is given a formula for a power constant by which the performance of gears may be compared.

In the section Steam Engineering are abstracted two articles, one on the discovery of leaks in surface condensers by chemical and electrical means, and the other on the design and use of steam engines with very high back pressures up to and perhaps over 60 lb.

In this article, by the way, the author calls attention to the unfortunate practice, still adhered to in many cases, of letting the consulting engineer design the power plant and then connecting up in a "traditional" way the appliances using live and exhaust steam in the various manufacturing processes carried in the plant. He shows further how much better results can be obtained when the entire plant is treated, as it ought to be, as a unit, and the power end designed with a clear understanding of what the exhaust steam is to be used for.

In the same article the matter of waste cylinder condensation, with special reference to engines working with high back pressures, is discussed in detail.

The question of pipe couplings with special reference to their use on gas line is taken up in an article abstracted from the *Natural Gas Journal.* Among other things is described a new type of a pipe coupling in which the outer flange is entirely done away with, and the ring is arranged in such way that it cannot bend between the bolts.

A plant in Brooklyn, N. Y., is described, where the entire feed water for the boilers and water for bathing and washing purposes is treated by the Permutit process. The installation is of interest especially because a capacity of about 500 cu. ft. takes care of 60,000 gallons per day of very hard well water, and only about 2000 gallons of brine (common unrefined salt) is used to treat it.

From a German publication is abstracted a paper on economic methods of packing metal shavings. The day is not far away when a lathe hand used to be proud of getting a shaving of record-breaking length. Now the problem is how to make it as short as possible, and the paper describes a number of ways, some apparently of proven practicability, of achieving this result.

The question of railway electrification as a solution of the smoke problem in Chicago is referred to in the last abstract. It is noteworthy in this connection that after a very thorough investigation, including an examination of a recent Diesel engine locomotive in Switzerland, no type has been found that could, even at a higher cost of operation, take the place of the

steam locomotive in work as heavy as that in the Chicago terminal zone.

Internal Combustion Engineering

UTILIZATION OF EXHAUST HEAT FROM INTERNAL COMBUSTION ENGINES, W. Gentsch

The problem of utilization of the exhaust heat from internal combustion engines has become of importance especially in connection with the introduction of Diesel engines for ship propulsion. It must be also remembered that in many cases a mixed Diesel engine and steam propulsion has been found advisable. Thus Thornycroft, on torpedo boat destroyers, have found it convenient to drive both screws by Diesel engines during maneuvering with about 1200 h.p., while in straight runs 15,000 h.p. are supplied to the shafts by steam turbines.

It is fairly clear that the exhaust gases cannot well be directly utilized in a turbine, since the driving medium possesses low specific gravity and comparatively low velocity, in addition to which, because of its low initial pressure, the velocity of the exhaust gases varies only very little.

An arrangement proposed by A. Burdin and M. Mutel is shown in Fig. 1 A and B. An explosion engine with rotary cylinders, and a turbine in series with it, rotate about a rigidly held shaft, and the exhaust valves of the cylinder are arranged in such a manner that the exhaust gases are discharged after each two revolutions of the cylinder during the period of ½ of one revolution. The purpose of this arrangement is that during the slow run of the pistons the exhaust gases still possess a sufficient power of expansion to drive the turbine directly, without the use of a superheater or similar device. The arrangement is shown in detail in the figure. Each of the working cylinders *E* rotating about the axis *B* is provided with an exhaust passage *m* governed by a valve *M*. In a disc *C* rotating together with the cylinder is provided a passage *m'*, which forms the continuation of the passage *m*. The turbine *P* is provided with blades *a* only over one half of its circumference. Since the engine works on the four stroke cycle, the exhaust gases from each cylinder can flow to the blades *a* only during one half of one revolution. The valves *A* are governed by the toothed wheel *N*. On the two opposite points of the disc *C* are rotatably located two other geared wheels *N'* and *N''*, each of which has twice as many teeth as the wheel *N* with which they are in engagement, so that when the working cylinder makes two revolutions, they make one revolution. The two wheels *N'* and *N''* have a roller *n* which during one quarter of a revolution of the geared wheels *N* and *N''* (that is during one half of a revolution of the rotating working cylinder) acts on the guide *N'* of a guiding frame, lifts it and thereby opens the exhaust valve *M* connected with it. The roller *n* operates in such a manner that the exhaust valves are alternately opened during one half of one revolution of the working cylinder, and during each complete revolution of the latter these exhaust gases are once directed towards the turbine blades *a*.

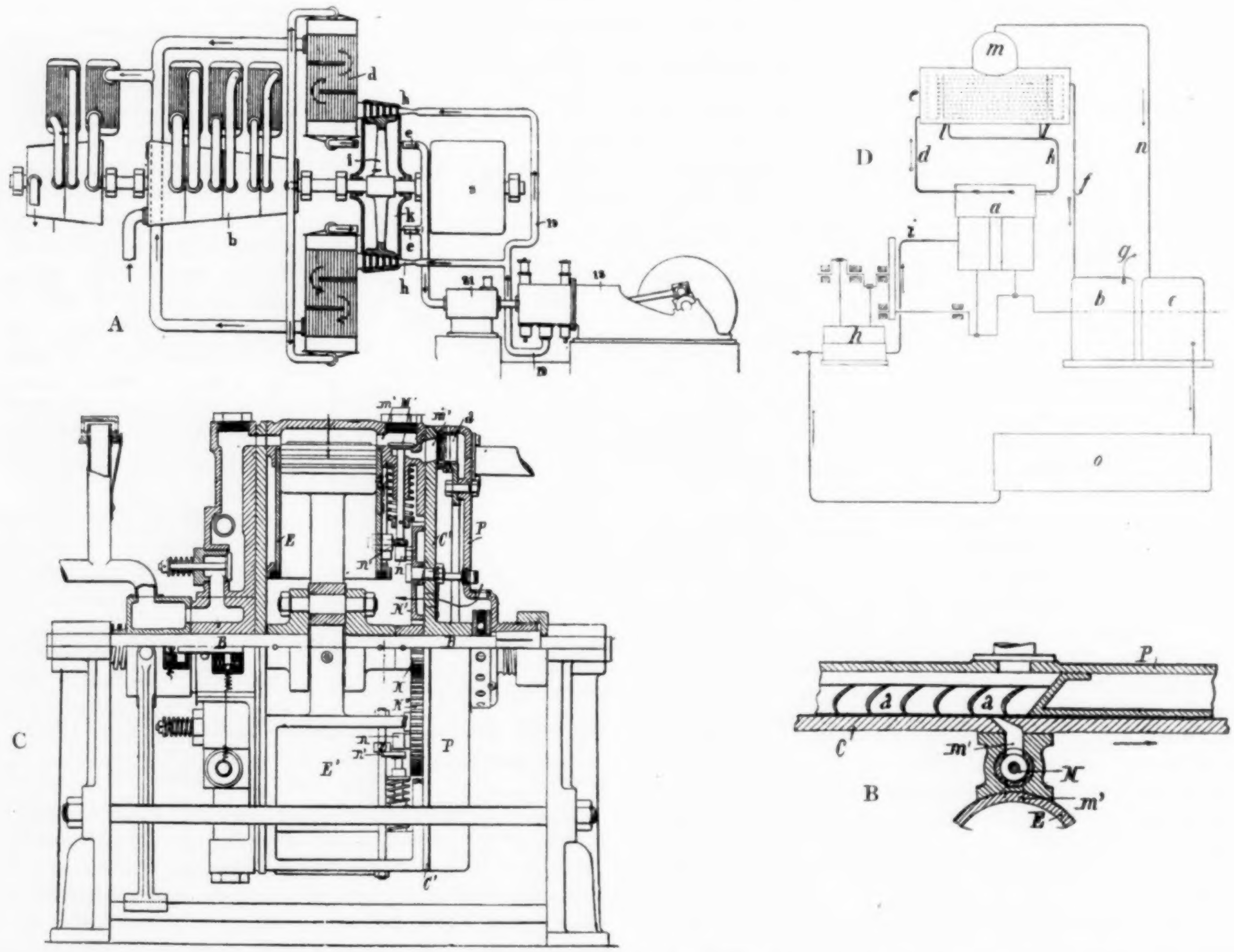

FIG. 1 APPARATUS FOR UTILIZING EXHAUST HEAT FROM INTERNAL COMBUSTION ENGINES IN PRIME MOVERS

In the design proposed by H. Grünewald (Fig. C), stationary cylinders working on the four stroke cycle are used, the shaft of which rotates a ring *a* provided with curved parts. This ring, in its turn, operates the cocks *v* through which fresh mixture is delivered by suction into the cylinder and the exhaust gas is liberated during the last stroke. During this delivery of the exhaust gas the fresh mixture which still remains in the cocks is ignited so that the gases still having a certain amount of energy are delivered into the running wheel of the turbine.

It is, of course, entirely feasible to utilize both the waste heat of the cooling jacket and the heat from the exhaust gases, and this may be done separately, so as to have both sources of waste heat connected, so to speak, in parallel. Fig. D shows diagramatically such an arrangement proposed by C. H. J. Stuart, in which the heat carriers, steam from the cooling water and gases work separately in the turbines, but previous to the delivery of the work there occurs between them an exchange of heat. The reciprocating engine *a*, the gas turbine *b*, and the steam turbine *c* work on the same shaft. The exhaust gases from the reciprocating engine *a* go through piping *d* into the heater *e* and from there through pipe *f* into the turbine *b*, from which they finally exhaust through pipe *g*. The pump *h* through pipe *i* delivers water into the cooling jacket of the reciprocating engine, which this water leaves, partly mixed with steam and material heated up, through pipe *k* and from there enters in the form of a spray the heater *e* through nozzles *l*. Here a complete vaporization of this water takes place, accompanied by a cooling down of the exhaust gases, this occurring in such a manner that the superheated steam flows through pipe *n* to turbine *c*. The exhaust of the latter goes to the condenser *o* out of which the pump *h* delivers it as water of condensation back to the cooling jacket. These three sets of machinery may be distributed between ship shafts in such a manner that the middle shaft is driven by the reciprocating engines while the two turbines drive the side shafts. This arrangement has the advantage that each working medium operates under conditions most suitable for it, but its disadvantage lies in the complicated arrangement which materialy increases the prime cost as compared with the gain in heat efficiency. (*Über die Verwertung der Abwärme von Verbrennungsmaschinen in Turbinen*, Wilhelm Gentsch, *Zeitschrift für das gesamte Turbinenwesen*, vol. 12, no. 33 and 34, pp. 385 and 397, November 30 and December 10, 1915, 8 pp., 14 figs. *d*.)

Machine Shop Processes

Manufacturing Brass Cartridge Cases for 18 Lb. Shells

When the problem of producing brass cartridge cases first came before Canadian manufacturers, one of the chief drawbacks to immediate output was the inability to secure the necessary equipment. The existing machinery of plants had to be adapted to the purpose, with eminent success in some cases, one of which is described here.

The work of producing brass cartridge cases for 18 lb. shells is characterized by some interesting drawing operations which with the annealing processes constitute the greater part of the work, especially in view of the fact that the metal from which these cases are made has to conform to close physical specifications after being worked and the finished case has also to pass a rigid inspection and answer to very exacting requirements. The article describes the processes of cupping, annealing the shells, first and second redrawing operations, first indenting, third and fourth redrawing and second indenting, fifth redraw and preliminary trimming, final trimming, heading the cases, annealing and tapering, machining the headed end, and inspection at the various stages of manufacture. The interesting feature of the manufacture described is that it is done not on special tools but with the usual equipment of a well-found machine shop. (*Canadian Machinery*, vol. 14, no. 27, p. 595, December 30, 1915, 6 pp., 17 figs. *dp.*)

Making Cartridge Cases on Bulldozers and Planers, Douglas T. Hamilton

The manufacture of cartridge cases on bulldozers and planers is described in detail step by step. A very interesting table is also given covering such data as the character of each operation, the sizes, type of machine used, type and temperature of furnace used, bath, scleroscope reading, and production per hour. The description and sizes refer mainly to the 18 lb. British cartridge case, but would be of equal interest for articles of approximately the same sizes with suitable modifications in the dies. (*Machinery*, New York, vol. 22, no. 5, p. 386, January 1916, 5 pp., 13 figs.)

The Production of Die-Pressed Castings, Edward K. Hammond

The production of die-pressed castings is a comparatively recent method of manufacture. Until recently, the production of many machine parts was limited practically to one of two methods: either turning the pieces from bar stock, or casting them in sand molds. The disadvantage of the former method lies in the large proportion of the material that is converted into scrap, while castings produced in sand molds are apt to be defective from several causes. The method of making die-pressed castings gives castings which can be brought extremely close to the required dimensions of the part with a smooth surface and uniform structure of the metal, and still be free from such defects as blow holes, pin holes, etc. Brass, bronze, copper, aluminum, nickel and other metals lend themselves to this treatment.

The article describes in considerable detail the dies used for this method and gives many suggestions in regard to the design of the dies, such as methods for determining the unit pressure which the die will be called to resist. It discusses also the design of dies made in halves for the case where the metal is completely enclosed.

Tungsten steel is the material best adapted to the requirements of making dies for pressing hot metal, but on account of its cost the expedient has been adopted of making the inner part of the die of tungsten steel and shrinking one or more machine steel collars around it to give it the required strength.

The type of power press used for applying pressure to the dies is further discussed. The author particularly recommends the "percussion" type of power press for use in the manufacture of die-pressed castings and describes certain types used in Germany and recently introduced into this country. The importance of performing pressing operations at a suitable speed is emphasized.

In this connection the author calls attention to the interesting fact that the lead of the driving screw does not govern the force of the blow which is delivered by the ram. By reducing the lead of the screw the speed of the ram and the value of its kinetic energy are correspondingly reduced, but this loss of power is offset by the fact that the screw of more gradual lead has a greater mechanical driving power. In practice the presses are designed to take advantage of the maximum mechanical driving power which can be obtained from the screw, and so the lead is made as small as possible, the limiting con-

dition being that point where the inclination of the thread is so gradual that the screw will tend to bind in the nut.

The raw materials of the industry are further discussed and a shop equipped for making die-pressed castings is described. (*Machinery*, New York, vol. 22, no. 5, p. 363, January 1916, 8 pp., 16 figs. *d.*)

Machine Tools

THE LARGEST HERRINGBONE GEAR HOBBING MACHINE, E. K. H.

Description of a special machine designed and built by the Falk Co. of Milwaukee, Wisconsin, for generating herringbone gears of the Wuest type.

For a description of the Wuest type see Transactions, Volume 33, page 681. The machine is equipped with two hubs carried by heads located at opposite sides of the table on which the work is mounted. (*Machinery*, vol. 22, no. 5, p. 396, January 1916, 3 pp., 7 fig. *d.*)

TYPICAL TOOLS AND DEVICES FROM CANADIAN SHELL SHOPS

The Canadian Pacific Railroad Angus Shops have developed a method for milling the back ends of the shell forging on a vertical milling machine by means of a special fixture not fully described. It requires about two minutes to complete one base and the operation is practically continuous as finished shells can be removed and rough ones put in place while the machine is running.

The Montreal Locomotive Co. is using a planer for facing off the bases of 4.5 shells. A heavy forging having a series of V's or notches cut in it is clamped to the planer bed. The shells are placed in the V's, three shells to each, and are gaged for length by having the noses "butt" against the bar fastened to the inside edge of the forging. They are then securely clamped by a heavy bar extending along the top. In machining the bases the side-head with vertical feed is used.

The Toronto Structural Steel Works use an interesting design of centering jig. It consists of an upright arbor fastened to a block which slides in V's formed on the table of the drill press. A bushing shaped to conform to the rough bore of the forging near the base slides on the arbor and is maintained in position near the top by means of a spring resting upon a shoulder formed by the lower part of the arbor. There is also provided another bushing which is made a sliding fit for the lower part of the arbor and is also held in its highest position by means of a spring. This bushing is made with a suitable taper so as to rest half way into the open end of the forging. When the rough forging is placed over the arbor it centers itself on the two bushings which compresses the springs until the weight of the forging is taken by two stop pins. The centering proper is done by a combination drill and center.

A number of expanding mandrels have been devised for shell manufacture. The Canadian Ingersoll-Rand Co. uses on an engine lathe a mandrel operated by air. A hollow arbor has a tapered shank to fit the lathe spindle. A plug screwed into the end of the arbor acts as a locating stop. Two sets of jaws are operated by means of a hollow sleeve and shaft. These sets of jaws are operated by a small air cylinder placed on the end of the lathe. When the air is turned on, the piston is forced back in conjunction with the shaft and sleeve. The tapered portions on the end of these engage with the taper jaws, forcing them out against the wall of the shell. E. T. Spidy has designed a mandrel to average up the hole, to take care of cases when a long hole is not perfectly straight. (*Canadian Machinery*, vol. 14, no. 27, p. 650, December 30, 1915, 5 pp. *d.*)

NEW MACHINES AND APPLIANCES EVOLVED BY CANADIAN FIRMS

Description of new machines and appliances evolved in Canada mainly in connection with the manufacture of shells.

John H. Hall & Sons have redesigned their cutting-off machines so as to adapt them to shrapnel and high explosive shell work. The bed of the machine is heavily constructed and to it is bolted the head stock. The spindle rests in ample bearings, the whole being entirely inclosed by a cast iron cover. The cut-off slide is provided with two tools working in opposite directions, and power feed. Longitudinal travel of the tool slide is obtained by means of a screw and star wheel located at the end of the machine.

The Hamilton Gear and Machine Co. have also redesigned their cutting-off machine. An annular chuck with automatic jaws grips the shell body leaving both ends exposed. Two tool slides are provided, one on each side of the chuck, the slide at the back carrying a tool which removes excess metal from the shell base, while the front slide carries a cutting-off tool which trims the shell to correct length.

The R. McDougall Co. makes an expanding chuck with the hand wheel fitted to a rod which extends through the hollow lathe spindle. Two sets of three jaws expand and tighten against the shell, which is pushed on the chuck until the end of the lathe which acts as a stop, comes in contact with the bottom of the shell. The jaws are caused to expand by two tapered lengths of the central spindle of the chuck. First, a stiff spiral spring which acts as a means of adjustment, is placed between the two tapered portions. As the small pair of jaws is designed to seize just before the larger, the spring allows the tapered portion of the spindle to continue to tighten the larger jaws. Flat steel springs withdraw the jaws from the work when the hand wheel is turned.

John Bertram & Sons Co. have designed a waving and hand-cutting fixture which may be attached to any style of lathe. A triple faced cam is attached to the face chuck holding the shell. The tool holders are bolted to the ways of the lathe, the front holder supporting the waving tools and the rear holder the under cutting tools, cams imparting an oscillating motion and giving a wave to the ribs. A stop in the center of the fixtures regulates the depth of cut for all the tools.

Two new nosing presses have been put on the market, one by the Brown-Boggs Co., a standard gear straight side press with a heavy nosing die attached to the end of the ram, and the other by the Canadian Locomotive Company, who found a way to convert their banding press into a nosing press simply by inserting a steel plug in the center of the machine. This plug is provided with a shank which extends down and rests on top of the piston from whence it gets its motion. The nosing die is held in a fixture mounted on the center of the machine. The shell is placed on the plug and moved upward, the nose coming in contact with the die which forms it to the desired shape.

A machine of novel design is the mechanical plug wrench developed by the Holden-Morgan Co. for screwing home the plugs in the bases of the shells. The bed of the machine is a hollow iron casting supporting two spindle bearings and a table for the vise. A large spur gear is keyed to the end of the spindle and is driven by a pinion on the clutch shaft placed at the side of the bed. The chuck on the spindle is made to take the square end of the base plug.

The Canadian Locomotive Company has also designed an

interesting type of painting machine in the shape of a huge drum on the top of which is mounted a circular table resting on five rollers, three of which are made of laminated leather and impart a revolving motion to the table. Mounted around the outer edge of the table of the machine are sixty hinged bolts. The brass sockets which are screwed into the shell nose are then slipped over the bolts, nose down. A bracket to carry the paint can be slipped over the central stationary spindle of the machine and can be moved around to any desired position. The operator swings the shell inward upon the hinged bolts and this causes the beveled surface of the brass casting in the shell nose to come in contact with the large central revolving disk. The shell is thus rotated and the paint applied with great ease. Steam coils are placed in the center of the machine which permits the shell to be dried very quickly. (*Canadian Machinery*, vol. 14, no. 27, p. 641, December 30, 1915, 3 pp. *d.*)

Materials of Construction

Recrystallization of Cold-Worked Alpha Brass on Annealing, C. H. Mathewson and Arthur Phillips

The paper is devoted to a limited report of some tests on the mechanical properties and micro-structure due to annealing under uniform conditions of certain types of commercial rolled brass. Since these experiments were conducted with the active coöperation of the Bridgeport Brass Co., involving free use of its product, and have thus furnished information which is characteristic of some of its special mixtures, the author does not consider justifiable the full publication of the numerical relationships and comparative results encountered. The present paper reports, therefore, only some of the general features of the work done, especially the characteristics of recrystallization as related to the degree of hardening by strain and the ordinary annealing variables.

The paper reports fully the results obtained by the French engineer, Grard, in 1909, as well as the experiments of Bengough and Hudson in 1910. It also describes the various methods used in the present tests.

The author states that the precise nature of the changes which take place in worked metal as a result of exposure to very moderate temperatures or even spontaneously is not understood. Any attempt to study these changes with the aid of the microscope is certain to fail because the accompanying structural alterations are too minute or too indefinite to be followed. Since no alteration of structure can be associated with these effects they must be of a mechanical nature (Heyn) or must be due to some reorganization of the particles which does not suffice to change the etching characteristics of the metal.

As reported in the paper, the investigation covered, in the first place, the determination of the time required at a number of different temperatures between 225 deg. cent. and 325 deg. cent. to produce a drop of three points in scleroscopic hardness in the case of 70/30 brass which has received a 40 per cent reduction by rolling after a dead soft anneal in the mill. The author calls attention to the fact that from a practical standpoint, if we are to speak of a critical temperature at which softening will begin in any particular mixture that has been given a stated reduction by cold working, certain qualifications have to be considered. Any set of curves giving the physical properties of a commercial mixture having anneal for a fixed period of time following a given reduction by cold working, requires that a stated period of anneal be rigidly adhered to within the critical range of incipient effects, in order that the results of the test may be properly duplicated. At high temperatures approximate equilibrium values are reached in comparatively brief periods of time. Thus in the case of cartridge brass (70/30 + 3) which has received a heavy reduction, at all temperatures above 325 deg. cent., variation of the annealing period between ½ hour and 1 hour will not bring about any material change in properties.

As regards the earlier stages of recrystallization in material which has received a high degree of reduction by cold work, microscopic examination under high power is necessary as the first visible elements of recrystallization are extremely minute. The intergranular secondary construction due to deformation consists in the main of groups of curved or wavy lines which possess the same general direction in each grain or homogeneous portion of a twinned grain and increase in number and prominence with the degree of reduction. It appears that in the squeezing of the grains between the rolls, the most destructive movements affecting the integrity and homogeneity of the grain-substance have occurred chiefly along the gliding planes which in any grain are nearest at right angles to the direction of elongation. The author calls them lines of deformation.

In a recrystallized structure free from mechanical alteration each homogeneous member or grain shows its individuality on etching by reason of its directional properties which determine selective etching with boundary distinction or selective reflection with contrasting effects. When the grains are strained beyond the limit of elasticity their temperature range of existence without visible change of form is restricted, and on heating to a high enough temperature they appear to disintegrate into smaller grains. An increase in surface energy due to "spontaneous" disintegration must have developed as a result of the strain, that is, in the form of inner surfaces between blocks or groups of the grain substance, but this mechanical dislocation of the grain substance is not indicated in any way by etching except in cases of severe strain. We cannot see the inner surfaces, all we can do is to speculate as to their nature; in fact, a sample of brass which has been heated to 750 deg. so as to develop a coarse grain and then strained so as to show numerous slip bands on the polished surface gave little or no evidence of recrystallization after annealing at approximately 600 deg.

On the whole, after a heavy reduction of metal by rolling, recrystallization begins in the more severely strained areas at low temperature the exact values of which in any case depend upon the degree of reduction and time of exposure. As the temperature of anneal increases under otherwise uniform conditions, additional etch bands break down or granulate, the existing recrystallization units coalesce and grow and at no very elevated temperature the entire pre-existing grain structure becomes replaced by a secondary refined structure.

A few special experiments were made for the purpose of revealing the characteristics of recrystallization in metal which has received very light reduction. From the standpoint of potential recrystallization the chief distinction between metal which has received a heavy reduction and metal which has received a light reduction lies in the vast difference between the number of inner surfaces which have developed in the two cases. These inner surfaces cannot remain permanently in existence under changing conditions and as the temperature is raised they give way to more stable configurations in accordance with equilibrium requirements which take into account their number, character and distribution along with the other variables encountered. Two neighboring particles with separate surface boundaries will tend to flow together under the

influence of forces which operate to reduce the surface area and surface energy to a minimum.

This tendency is opposed by forces which bring about a certain degree of rigidity of the grain-substance or determine directional properties which each particle tends to retain. In this way there tends to be established a condition of equilibrium beyond which further decrease of surface area is effectively opposed by the forces in question. This form of equilibrium renders the size of particles of a number of inner surfaces chiefly a function of the temperature. In order that reorganiaztion within the grain-substance may proceed at a low temperature, there must be a high order of development of inner surfaces, but where the metal has received a light reduction there are no inner surfaces of this order and the first units to recrystallize will be comparatively large.

As to the principal relations between deformational treatment and structural characteristics after anneal, the author states that no direct indication of the size or shape of the ultimate secondary units can be obtained and as far as direct observation goes these new structural elements are latent only. In order that the annealing effect may be felt at the given temperature, the mechanical destruction of the original grain must have been sufficiently pronounced to produce fragments inferior in size to the recrystallized grain characteristic of this temperature. In general the grain fragments produced by deformational processes will vary widely in size, so that certain of them will be able to coalesce below the given temperature, while others will remain unaffected, the particular factors which apply in any given deformational process will combine to determine a curve of fragmental resolution of grains for this particular process in which the cumulative percentage of fragments below a given size appears as a function of the size of the fragments.

As the degree of deformation increases through mechanical working, the curve of fragmental resolution recedes in the direction of maximum resolution, a specific condition for each metal or alloy beyond which further destruction of grain will bring about fracture. There is for each metal or alloy a minimum temperature at which recrystallization will start from a condition of maximum resolution into fragments of minimum size. On the other hand, in metal which has received very light deformational treatment, the curve of fragmental resolution assumes a form in which the percentage of coarse fragments will very likely exceed the percentage of fine fragments. It must be borne in mind, however, that the curves of fragmental resolution are purely hypothetical. The precise form of any curve will be determined by the nature and intensity of the deformation sustained by the metal.

The paper contains an interesting discussion of the structural changes developed in 70/30 cartridge brass by uniform anneal at six different temperatures within the range 350 to 800 deg. cent. after reductions of 2, 4, 8, 12, 15 and 25 per cent respectively. The characteristics of rolled structures are illustrated by photomicrographs. (*Bulletin of the American Institute of Mining Engineers,* no. 109, p. 1, January 1916, 50 pp., 4 figs and 11 plates. *etA.*)

Rusting of Iron and Steel, James Scott

Discussion of the subject of rusting of iron and steel based on observations made on iron fixed so that the surface rust can develop undisturbed.

Invisible globules of moisture falling upon iron react with the particles in their vicinity. Should several of these globules run together they form a small pool in which the specks of rust are so deposited that when all parts are dry there is an elevation inside the crater resembling a minute exhausted volcano. (Fig. 2.) When iron oxidizes, it increases in bulk so that it becomes capable of forcing any covering off. Particles of rust may emerge from invisible cracks in an apparent protective coating. The continuous spreading of the rust causes the paint to peal away, giving rise to the opinion that this latter substance is at fault. Actually iron expands and contracts according to temperature, and unless the paint which covers it has the same elasticity it will split at various points and thereby enable the globules of steam to settle down on the granules of the metal; if neglected the final result will be disastrous.

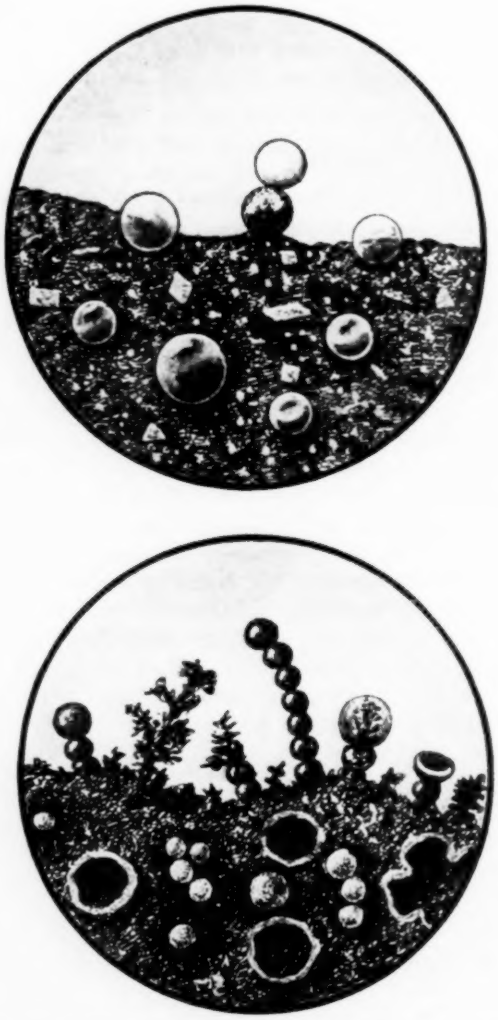

Fig. 2 Magnified Globules of Rust on Iron and Steel

The less disturbed the metal is, the more perfect become the rust spheres and "necklaces." The inside of the eye of a rusty needle, for instance, where the substance is shielded from dislodgment, will generally present a series of elevated necklaces and the same objects can be purposely obtained within a few days on any kind of iron.

It is usual to refer to the wet rust as ferric hydroxide and to dry rust as ferric oxide. The author claims that when iron rusts it has first to pass into a ferrous condition (green in color) which then rapidly oxidizes to the red or ferric condition. These changes can be watched by immersing a strip of iron for a few days in a small jar of water the upper portion being allowed to project.

A very beautiful experiment may be undertaken to empha-

size the electrolytic theory. Soften some pure gelatine, such as agar-agar in hot distilled water. Exactly neutralize the solution with 1/100 normal caustic potash, meantime using phenol phthaleine as an indicator. Then add a few drops of potassium ferrocyanide to the jelly and pour a layer of the compound in a shallow dish standing in ice water, which will rapidly stiffen it. Lay a strip of clean iron in the jelly and cover some more over it so as to wholly immerse the metal. Keep the whole in a cool, dry place; the moisture in the gelatine will be sufficient to induce oxidation.

Within a short time the electric action will begin. Dark blue patches of color in the form of spheres and ellipsoids (Fig. 3) will appear and indicate the positive poles, while dark pink zones somewhat hazy and glistening will denote the negative poles. The blueness is caused by the combination of ferros iron with the ferrocyanide, making what is practically Prussian blue. The pink is the infused oxide rendered delicate by the presence of the gelatine. The blue areas gradually become red owing to the deposition therein of the true ferric oxide. The changes in color will continue until exhaustion sets in. The less pure the iron is the sharper will be the definition. (*Railway Engineer,* vol. 36, no. 431, p. 329, December 1915, 3 pp., 3 figs. *et.*)

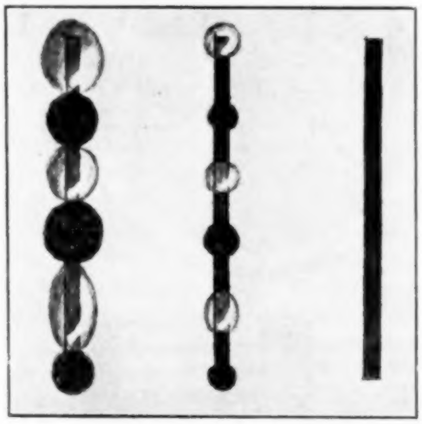

FIG. 3 SPHERES AND "NECKLACES" OF RUST

Mechanics

BENDING OF A SHAFT HAVING TWO BEARINGS, J. Cabrol

Assume a shaft of any shape whatsoever, subject to a certain number of vertical loads, P_1, P_2, etc., distributed in any manner whatsoever, and producing counter reactions V_1, V_2, etc. The supports are assumed to be free. We use the following notation:

x, abscissa of a section X measured from the axis of the left bearing,

y, deflection of the shaft from the lead-line of that section,

M, moment of bending,

I, moment of inertia of the section.

Then
$$\frac{d^2y}{dx^2} = -\frac{M}{EI} \qquad \ldots\ldots\ldots\ldots [1]$$
where E is the modulus of elastiicty of the metal of the shaft. The calculation of the shaft reduces itself therefore to the integration of this differential equation of the second order in which the second member is a function of x. This is usually done either graphically or by successive differentiations, but the author gives a method which simplifies it to a certain extent. $\frac{M}{EI}$ or $\frac{M}{I}$ is a function of x, and, as shown in Fig. 4, is of quite irregular shape. We can, however, consider it as a first half-period of a periodic function (period $2l$), and as such develop it into a Fournier series. There is nothing to prevent us from assuming that the second half-period will be similar to the first one, and hence the developed series will contain only odd harmonics. We have, therefore:

$$\left.\begin{array}{l} \frac{M}{I} = A_1 \sin\frac{\pi x}{l} + A_3 \sin\frac{3\pi x}{l} + A_5 \sin\frac{5\pi x}{l} + \ldots \\ \quad + B_1 \cos\frac{\pi x}{l} + B_3 \cos\frac{3\pi x}{l} + B_5 \cos\frac{5\pi x}{l} \end{array}\right\} \ldots\ldots [2$$

In this equation, by the way, the cosine terms will disappear only when the curve $\frac{M}{I}$ is symmetrical to the perpendicular section of the shaft through its support, which is an exceptional case. But, from equation [1]

$$\frac{M}{I} = -\frac{Ed^2y}{dx^2}$$

By integrating it twice we get

$$\left.\begin{array}{l} y = \frac{1}{E}\left(\frac{l}{\pi}\right)^2 \left[A_1 \sin\frac{\pi x}{l} + \frac{A_3}{9}\sin\frac{3\pi x}{l} + \frac{A_5}{25}\sin\frac{\pi x}{l} + \ldots \right. \\ \left. B_1 \cos\frac{\pi x}{l} + \frac{B_3}{9}\cos\frac{3\pi x}{l} + \frac{B_5}{25}\cos\frac{5\pi x}{l} + \ldots \right] + Cx + D - \end{array}\right\} \ldots [3]$$

C and D are constants of integration. To determine them, we take that y becomes zero when $x = 0$ and when $x = l$. This gives us:

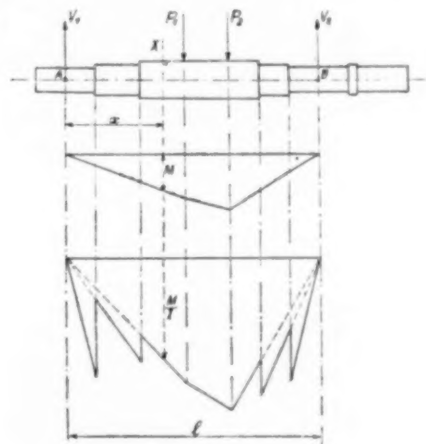

FIG. 4 CURVES OF M/EI AND M/I FOR A SHAFT HAVING TWO BEARINGS

$$0 = \frac{1}{E}\left(\frac{l}{\pi}\right)^2 \left[B_1 + \frac{B_3}{9} + \frac{B_5}{25} + \ldots \right] + D$$

$$0 = \frac{1}{E}\left(\frac{l}{\pi}\right)^2 \left[-B_1 - \frac{B_3}{9} - \frac{B_5}{25} - \ldots \right] + Cl + D$$

and hence

$$D = -\frac{1}{E}\left(\frac{l}{\pi}\right)^2 \left[B_1 + \frac{B_3}{9} + \frac{B_5}{25} + \ldots \right]$$

$$C = -\frac{2D}{l}$$

If we substitute these values into eqaution [2], we obtain:

$$\left.\begin{array}{l} y = \frac{1}{E}\left(\frac{l}{\pi}\right)^2 \left[A_1 \sin\frac{\pi x}{l} + \frac{A_3}{9}\sin\frac{3\pi x}{l} + \frac{A_5}{25}\sin\frac{5\pi x}{l} + \ldots \right. \\ -B_1\left(1 - \frac{2x}{l} - \cos\frac{\pi x}{l}\right) - \frac{B_3}{9}\left(1 - \frac{2x}{l} - \cos\frac{3\pi x}{l}\right) - \\ \frac{B_5}{25}\left(1 - \frac{2x}{l} - \cos\frac{5\pi x}{l} - \ldots\right) \end{array}\right\} [4]$$

If we take $x = \frac{l}{2}$ we have an expression for the flexure at equal distances from the supports which is particularly simple and, in general, sufficiently close for all practical purposes to the value of maximum deflection:

$$f = \frac{1}{E}\left(\frac{l}{\pi}\right)^2 \left[A_1 - \frac{A_3}{9} + \frac{A_5}{25} - \frac{A_7}{49} + \ldots \right] \ldots\ldots [5]$$

The terms with B disappear entirely. It is therefore after all a problem of resolving a periodic curve into its harmonies which can be done in several ways which the article discusses. *Méthode de calcul de la flèche d'un arbre reposant sur deux tourillons*, J. Cabrol, *La Lumière Electrique*, vol. 37, no. 49, p. 265, 3 pp., 1 fig. *m.*)

Lubrication of Bearings and Cylinders, F. L. Fairbanks

The author discusses some of his experiences in the matter of lubrication of bearings and cylinders and describes what he considers the correct methods of design of bearings. He also reports certain experiments with various kinds of lubricating oils.

In the first place, he tried to determine the probable thickness of the film of oil under a joint or piston. He found that under normal running conditions the average film of oil under the shaft was from 0.002 to 0.003 in. and that the thickness of the film depended considerably upon the rotative or circumferential speed, the thickness increasing with the speed probably because more oil is pumped or pulled in between the journal and the bearing as the speed increases. As a result of this experiment the plant with which the author is connected gives the average journal 0.005 in. clearance and to eliminate hand work, machines the bearings 0.005 large and then takes out the shims that are placed between the cheek pieces and the upper and lower shell after the machining. This gives a shape of bearing almost identical with the hand shaped bearing.

The author objects to the use of the usual type of oil grooves in bearings. He says that several babbitted bearings which ran warm did not begin to run cool until after they started the babbitting and filled the oil grooves. He believes that the average oil grooves are of comparatively little value because they represent usually a journal with square edges.

To make the groove more efficient the author decided to cut it as shown in Fig. 5 A so as to get rid of the corner at the edge of the groove and obtain a wedge shaped opening from either side down.

In experiments with oils of approximately the same "tensile strength" (viscosity), different results were had, which indicates that there are two qualities that represent the lubricating properties of oil, *viscosity* (which the author calls also "tensile strength") and *adhesiveness to the metal surfaces.* As animal oil is more adhesive it, instead of slipping on the surfaces, is carried under the shaft, but beyond a certain temperature point animal oils lose their viscosity faster than the mineral oils. Russian oil was found to be more viscous and hence preferable to American oil.

The author describes how the bearings are made and calculated in his plant. To further insure safety, all of his bearings now have a special bronze with diagonal babbitt inserted (Fig. B). He takes a bottom shell and runs diagonal strips of babbitt, the idea being that these strips will wear usually under the surface of the bronze as the oil apparently has a greater affinity for a good babbitt than for brass. Besides if an oiler through carelessness allowed the bearings to run dry or with too little oil to carry the film around the shaft these diagonal inserts of babbitt would melt and immediately become a lubricant. Incidentally they raise the shaft and protect it from the bronze bearing. In this connection the author describes the particular case of babbitt melting through the fact that an oiler apparently dropped a piece of waste into the hole on a bearing of a 1000 ton compressor before replacing the strainer.

The author describes also an interesting case where kerosene added to the lubricant caused serious trouble. The oiler held that an engine running constantly will get "gummed up." He thought it a good idea to put in kerosene and wash out the bearings which he did by pouring in a pint to the center crank pin bearing with the compressor working at 200 lb. pressure. The engine soon stopped and on inspection it was found that every bit of babbitt in that center crank pin was wound around the shaft. The bearing looked worse than if the box had been filled with gravel, but after the babbitt was filed off there was hardly a scratch under it. The author thinks, therefore, that the babbitt is the best safety valve for friction that he knows of.

The question of cylinder lubrication has been also treated

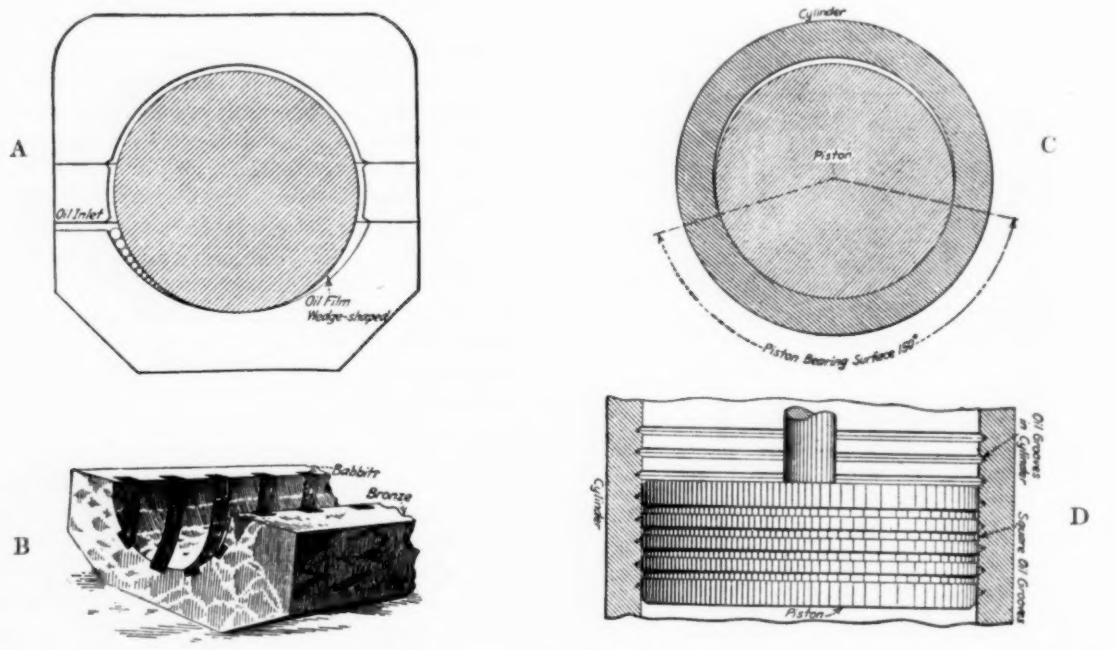

Fig. 5 Lubrication of Bearings and Cylinders

in the same manner. The author had a 60 in. low pressure cylinder, out of which hardly ever more than three months' use was obtained. The cylinder carried a very heavy piston weighing 3 to 5 tons with its portion of the rod. The average engine builder carefully bores out cylinders, in fact, some grind them, and then turn up the pistons with 1/32 to 1/16 in. clearance which gives a circle within a circle, and as both elements are cylinders, the weight is borne on a line. The result is that the builder has anywhere from a few pounds to 5 or 6 tons per sq. in. projected area and it is the distortion of the cylinder that really helps, by increasing slightly the bearing surface. As the cylinder approaches the original temperature of the casting it goes back to the original shape, the distortion being proportional to the difference in temperature and dependent upon the construction of the cylinder. If this is true why waste time grinding cylinders?

Instead the shop turned the piston which was 0.003 to 0.004 in. larger than the cylinder, jacked it off center and relieved it as in Fig. C, giving the maximum of 150 deg. The old piston has a little over 7 sq. in. of bearing. With a new piston nearly 9 sq. ft. were obtained.

On investigation the author found that the average low pressure cylinder is running in water. That is, there is water between the piston and the cylinder. He found that there is a film of water anywhere from ¼ to ½ in. in depth being pushed ahead of the piston. If this is true the oil must be on the surface and is not lubricating the point between the piston and the cylinder. To prevent this condition the cylinder was bored out leaving tool marks with 16 threads to the inch and looked something like Fig. D. A 60 in. piston was put in and has been running for the last nine years. To-day these tool marks are black and the piston and cylinder do not touch as the former runs on an oil film. The junk ring carries one ring of packing in the center as black as can be; where it overruns the packing ring the oil is gummed as it is on the back of a Corliss valve. The same principle is used on ammonia machines with 24 threads to the inch.

It was found that viscosity is lower in summer than in winter. The oil systems are logged every hour and once in 24 hours the viscosity and the gravity are taken. The reports come to the office every morning and are filed, the engineer being notified of every drop in gravity of one degree and a drop in viscosity of 10 points. This gives quite valuable information. The viscosity of oils are measured at 100 deg. which is taken as a standard temperature. By testing the viscosity of each oil at temperatures near or up to the working temperature it was found in the case of two oils that up to 350 deg. fahr. the viscosity of both the oils was the same but at a slightly higher temperature the viscosity of one of them dropped 40 points behind the other. (*The Isolated Plant*, vol. 8, no. 1, p. 21, January 1916, 4 pp., 4 figs. *ed.*)

FITTING EQUATIONS TO PLOTTED CURVES, Assistant Professor J. B. Kommers

The paper describes methods intended as an assistance for determining the equations which will fit curves obtained from experimental work.

The author begins by simple curves having no constant terms, parabolic, hyperbolic, and logarithmic, and shows how such curves can be converted into straight lines by plotting them on logarithmic or semi-logarithmic paper. He proceeds then to the consideration of equations of the same types but having one or more constant terms. Such equations, when plotted on logarithmic or semi-logarithmic paper, do not result in straight lines, and for handling them, the author suggests the ***method of selected points*** which makes use of as many sets of co-ordinate points on the curve as there are constants in the equation. Solving the simultaneous equation obtained by substituting these values, gives the complete trial equation which should then be tried for various values of x to see if it fits the other points on the curve. If say three sets of points are chosen, they should be taken from the beginning, middle, and end of the curve so as to cover the whole range fairly well. The author gives several examples to show the application of the method of selected points to experimental curves taken from various publications and therefore typical of the kind that are met with in practical work. (*The Wisconsin Engineer*, vol. 20, no. 3, p. 106, December 1915, 11 pp., 6 figs. *p.*)

HELICAL SPRINGS UNDER CENTRIFUGAL ACTION, John S. Myers

Investigation of a speed-limit device under conditions of operation where the weight of the spring is an important factor.

Most high speed machinery is now equipped with speed-limiting devices, the action of which usually depends on a

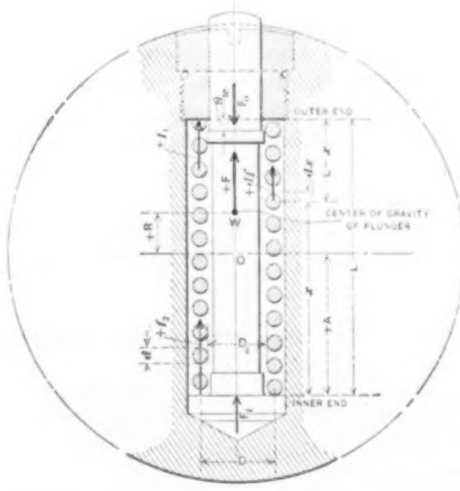

FIG. 6 SAFETY SPEED LIMIT DEVICE WHERE SPRING IS ACTED UPON BY CENTRIFUGAL FORCE

spring being deflected by the centrifugal force of a rotating weight; since the centrifugal force of the spring due to its own weight varies as the square of the velocity, the weight of the spring becomes of considerable importance at even moderately high speeds. The article presents a mathematical investigation of this matter and derives the following formula for the total centrifugal force of the spring (Fig. 6):

$$f = KwN^2(\tfrac{1}{4}L - \tfrac{1}{2}A) + KwN^2(\tfrac{1}{4}L - \tfrac{1}{2}A)$$
$$f = KwN^2(\tfrac{1}{2}L - A)$$

Where K = centrifugal force constant = 0.0000284; w = weight of spring; N = r.p.m. of devices about center O; L = length of spring in place under its initial strain; A = distance from the center of rotation to inner end of spring as shown in Fig. 6.

In this equation $(\tfrac{1}{2}L - A)$ is the distance from the center of rotation to the center of gravity of the spring. The author also discusses other forces acting on the spring, as well as gives an equation for the deflection of the spring. He proceeds then to a statement of the usual method of handling the designing of a spring and gives a numerical example illustrating it. (*Machinery*, vol. 22, no. 5, p. 400, January 1916, 4 pp., 2 figs.)

Power Generation and Transmission

Reciprocating and Rotary Principles in Prime Movers, Dugald Clerk

The paper is a reproduction of one of the Thomas Hawksley lectures, this time on the world supply of fuel and motive power. Among other things the author expresses an opinion that as far as he can see there is no hope of an indefinite increase in power using reciprocating pistons in internal combustion engines. Something must be done to introduce the rotary principle. So far the gas engine has not proved to be a success, but other methods of dispensing with the reciprocating piston and cyilnder are quite practicable. The large Humphrey engine dispenses with pistons, but is necessarily heavy for a given power. It appears, however, possible to use water in another manner by filling a chamber, exploding a compressed mixture above the water, and forcing the water through a jet to operate a turbine of the Pelton type. Arrangements would be made to allow for the varying velocity of the water due to the falling of pressure by expansion, and it would be quite possible to obtain an efficiency between the explosion chamber and the Pelton wheel of about 80 per cent. Such a turbine could be made to work using the same water repeatedly and high efficiency combined with light weight is possible. A brake efficiency of 30 per cent is possible, but before such engines could compete for the highest power reached by the steam turbine, gas producers must be considerably modified and improved. Producers will require to be designed which avoid the huge scrubbing plant required now in all bituminous producers.

The author gives the following interesting table showing the progress in the work of the engineer during the nineteenth and twentieth centuries.

Indicated Thermal Efficiency of Steam and Internal-Combustion Engine.

Steam.	Indicated Efficiency. Per Cent.
Boulton and Watt Condensing Low-Pressure, about 1820	3.8
Cornish Engine, about 1850	9.0
Triple Expansion, about 1910	17.0
Parsons Turbine, about 1914	23.0
Internal-Combustion.	
Lenoir, about 1860	4.0
Compression-Constant Volume (two or four stroke):	
1876	16.0
1905	35.0
Compression-Constant Pressure (Diesel), 1910	40.0

The indicated efficiency refers to the proportion of the total heat of the steam of working fluid given to the engine converted into indicator work. (Thomas Hawksley Lecture. The World's Supply of Fuel and Motive Power, Dugald Clerk, *The Journal of the Institution of Mechanical Engineers, Part* I (1), December 1915, 34 pp. *g.*)

Some Notes on the Comparative Costs of Compressed Air and Electricity for Use in Mine Stop Haulages, A. E. Middleton

While admitting the superior economy of electricity over compressed air for use on main and auxiliary underground haulages, the author questions the economy of electric drive on winches. He believes that although a considerable field is open for electrically driven winches in the flat mines on the eastern Rand, the heavy cost of cables is the chief adverse factor as regards their adoption. An electric coal cutter uses about the same horse power but works for longer hours, displaces expensive hand labor and can therefore carry a much higher first cost for cables. A substitute for the present safe and efficient, but expensive, paper or bitumen armored cable is highly desirable. The cost of power is decidedly in favor of electricity, but the first cost is likely to be in favor of air. The air has to be carried long distances to the working faces and the extra length and cross section required at any point for a winch is practically negligible, while apart from pumps and haulages generally situated on the main arteries of the mine, no electric power is available and the cost of extra cabling has to be debited entirely to the electric winch. (*The Transactions of the South African Institute of Electrical Engineers,* vol. 6, Part 8, p. 254, October 1915, 4 pp. *cp.*)

Farm Machinery Exposition

Description of the Exposition of the Smithfield Club at the Royal Agricultural Hall in Islington.

The Smithfield Club is mainly an agricultural organization, but at its Annual Shows farm machinery, tractors, and prime movers are exhibited. Among the machines shown this year, attention is called to the 3 to 4 ton gasoline wagon built by Clayton and Shuttleworth. The engine is a four cylinder machine developing 45 b.h.p. when running at a speed of 1000 r.p.m. The worm reduction gear is of the friction type. Power is transmitted from the propeller shaft by means of a worm and worm wheel to the differential casing. The propeller shaft is enclosed in a steel tube having ball joints at the rear end of the gear box thus relieving the springs of all driving strain. This tube takes the whole of the torque or drive of the rear axle. Roller and ball journals and thrust bearings are used throughout. Another of Clayton and Shuttleworth's exhibits is a five ton steam wagon fitted with rubber tires. The makers claim that in designing this vehicle special attention has been paid to steering capacity, the proportioning of parts and the distribution of load.

Ruston, Proctor & Co., Ltd., show among other things a ten b.h.p. engine for working with paraffin. It is one of the so-called convertible engines. It is fitted with a magneto and sparking plug and is started with gasoline. No starting torch is used. The engine may readily be converted to work with fuels such as benzole, gasoline, kerosene, producer and town gas.

Petters exhibited a light agricultural tractor for general farming work. The engine which starts on gasoline and afterwards runs on kerosene, is an 8 to 10 h.p. machine and can be fitted with a pulley for driving stationary machinery. Battery ignition is used for starting purposes. (The Smithfield Club Show, *The Engineer,* vol. 120, no. 3128, p. 550, December 10, 1915, 3 pp., 7 figs., articles not finished. *d.*)

The Geared Turbine and the Turbo-Electric Systems of Marine Propulsion, John H. Macalpine.

Data on design of transmission gears in geared turbine marine propulsion systems and a discussion of the comparative merits of the geared turbine, and turbo-electric ship drives.

The author derives what he calls the Power Constant by which the performance of gears should be compared. It is

$$C = \frac{1000\ P}{D^2\ R}$$

where C = power constant, P = horsepower transmitted by the gear, D = diameter of pinion in inches, R = revolutions per minute of pinion. The factor 1000 is introduced to make C fall, usually, between unity and 10. In similar gears loaded at corresponding points to the same intensity of stress the value of C is constant and with similar gears on a turbine of given power and speed, the weight per horsepower is inversely proportional to the value of C; hence the higher the value of C which can safely be carried the better the design or type of the gear and the more advantageous for adoption on board ship.

The "floating frame" was introduced to raise the safe value of C by producing and automatically maintaining very uniform distribution of pressure between the teeth and thus preventing great local rise of stress through slight errors of alinement of the gear and pinion. With the floating frame, errors of alinement unless far outside the limits which would ever be allowed to occur in practice, produce no sensible effect. The Westinghouse Machine Co. gradually raised this constant until $C = 4$ is regarded as a proper value for marine work. Then by reducing the pitch diameters of the Neptune's pinions to 7 in., C was raised to over 5 with complete success. It is worth remembering that the highest result for rigid gears is about 3 on the S.S. Vespasian. For a given power, the high value of C allows either a much smaller and lighter gear for a given ratio of reduction or, with a given diameter—of large gear, of a greater ratio of reduction, reducing the speed of the propeller or increasing the speed and consequently reducing the size and the weight of the turbine, and thus increasing the efficiency of the installation. (*International Marine Engineering*, vol. 21, no. 1, p. 4, January 1916, 5 pp., 2 figs. *dc.*)

Steam Engineering

Application of High Pressure Exhaust Steam to Manufacturing Purposes, James M. Taggart

The article compares the application of high pressure and of low pressure exhaust steam to manufacturing purposes from the point of view of safety and economy and describes a plant in which exhaust steam is used at a pressure of 60 lb. per sq. in.

The necessity for the use of high pressure steam in various manufacturing processes is due to the need of high temperatures. As examples may be cited the boiling down of certain liquids, melting of solids such as asphaltum, vulcanizing, drying, and rapid evaporation. Among the objections raised to the use of high pressure exhaust have been, first, that the increase in initial pressure would increase the cost of equipment; second, that the higher initial pressure would result in lower boiler efficiency and greater loss through radiation in the piping; and third, that the higher pressure involves an increased danger of accident or breakdown.

These objections are answered somewhat as follows: The increased cost of the equipment installed would ordinarily be more than offset by the reduction in size of the equipment required; because of the reduced size of piping the total loss would probably be no greater; as regards the increased danger of accident, at the present time the use of higher pressure has already led to the development of construction fully meeting the conditions and in a high pressure plant accidents may be as rare as in a low pressure plant. In fact, the purer condition of feed water in high pressure plants has often resulted in the decrease of accidents because of the practical elmination of scale.

It seems to be the common practice where steam for manufacturing purposes is required at a pressure of 40 lb. or more to use live steam direct from the boilers while the engine exhaust is run to the air or to a condenser. This is probably due to the usual separation of power design from the design of factory equipment. The consulting engineer is often retained to design the power house, and his duty ends with running a steam line to supply live steam for the factory, then the various appliances are connected up according to standard practice for the industry involved.

The author had a case in which the manufacturing conditions apart from the engine required steam at a pressure of 60 lb., the amount of steam used in the processes being normally twice what would be needed for power. The computation showed that all the exhaust could be easily utilized provided the initial pressure was not lower than 140 lb. per square in. At that time the investigation failed to disclose any instance where such back pressure had been used.

The installation was made as proposed and worked in practice as anticipated, in fact, with the cylinder condensation even lower than expected. The engine used was of the high speed automatic balanced slide valve type and the general arrangement of the plant is shown in Fig. 7A.

Fig. B shows some copies of indicator cards taken from the engine at various loads and at 65 to 70 lb. back pressure. At the lower loads the expansion line falls below the back pressure lines but flattens out when 10 to 12 lb. below. It was found that this point, namely 10 or 12 lb. below the back pressure, was about the limit to which the expansion curve fell no matter how light the load. It seems that the pressure must have been held up by evaporation, as the engine was tested for leakage.

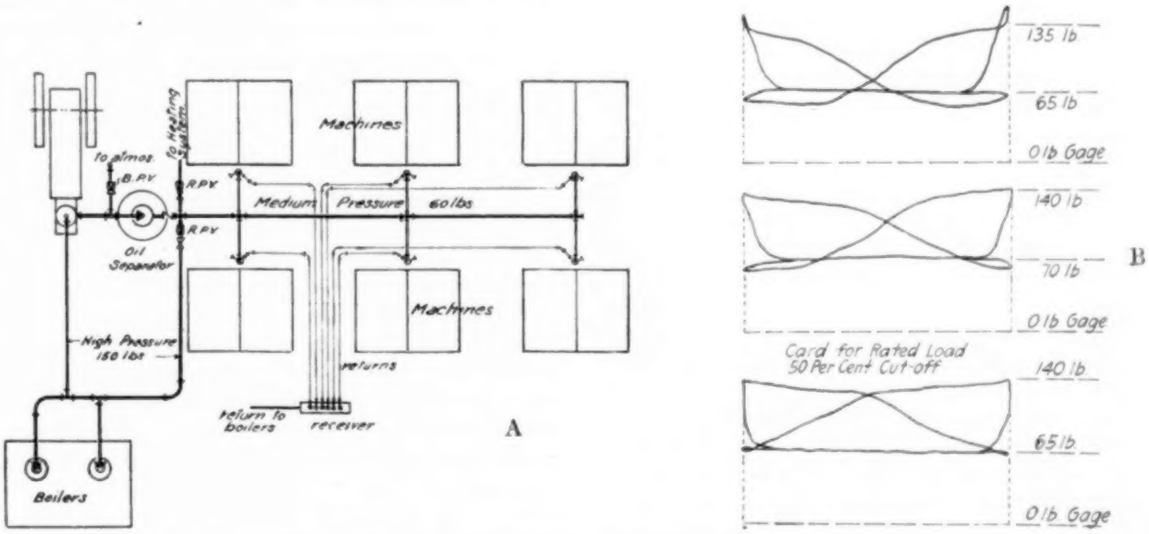

Fig. 7 Layout of a Plant Using Exhaust Steam at 60 Lb. Pressure, and Copies of Indicator Cards Taken at 60 to 70 Lb. Back Pressure

The article gives a table showing the various quantities computed from the tests and fully discusses the methods of computation. The matter of waste cylinder condensation is carefully considered on the basis of tests made at the Sheffield Scientific School of Yale University in December, 1914, by Prof. F. P. Breckenridge and Prof. E. H. Lockwood, as well as the tests made by Callender and Nicholsen. The author figured the weight of condensation on the actual weight obtained per h.p. because seemingly the inefficiency of the engine or the steam used per hp-hr. should not affect the condensation due to radiation for similar sized cylinders and similar power development.

In table 1 the quantities computed are, for convenience, all based on the assumption that $V\ N$, or the volume of the cylinder times the number of revolutions, is equal to 100. For any special use, the quantity in the table multiplied by the respective $V\ N$ and divided by 100 will give the equivalent quantity (*Steam*, vol. 17, no. 1, p. 7, January, 1916, 5 pp., 3 figs. *ed.*)

TABLE 1. VALUES FOR $VN = 100$

Initial pressure, lb. per sq. in.	Exhaust pressure, lb. per sq. in.	Cut-off in per cent of stroke	Mean effective pressure, lb. per sq. in.	Indicated horsepower	Steam per hp-hr., lb.	Thermal efficiency of system, per cent	Cost per hp-hr., lb.
200	20	19.5	78.3	68.3	20.5	64	0.49
200	40	28.0	81.8	71.2	27.1	63	0.50
200	60	37.0	83.1	72.5	33.8	62	0.51
200	80	47.0	79.5	69.3	42.8	61	0.52
180	20	19.5	74.1	64.7	21.7	65	0.49
180	40	30.0	76.0	66.3	28.9	64	0.50
180	60	43.0	75.2	65.6	37.3	62	0.51
180	80	53.0	69.3	60.5	48.7	61	0.52
160	20	25.0	69.4	60.6	22.7	65	0.49
160	40	33.5	69.2	60.3	31.5	64	0.50
160	60	48.0	66.7	58.2	41.5	62	0.51
160	80	59.0	58.2	50.8	57.3	62	0.52
140	20	29.0	64.0	55.8	24.3	66	0.49
140	40	39.0	61.8	54.0	34.7	64	0.50
140	60	54.0	56.9	49.6	48.1	63	0.50
140	80	65.0	45.8	40.0	71.8	62	0.51
120	20	33.0	57.8	50.3	26.6	66	0.48
120	40	44.0	53.3	46.5	39.9	65	0.49
100	20	39.0	50.5	44.1	29.9	67	0.48
100	40	52.0	43.2	37.7	48.4	66	0.49

HUNTING FOR LEAKS IN SURFACE CONDENSERS, Otte

The development of the steam turbine has led to an increased use of surface condensers instead of the formerly more extensive use of jet condensers. One of the great difficulties which is encountered in the use of surface condensers is that of keeping the condenser space watertight with respect to the cooling water, since with even a few leaky places quite considerable amounts of cooling water may penetrate into the water of condensation. This entails the following undesirable consequences:

1. The condenser pump is loaded higher than it should be, since, in addition to the water of condensation, it has also to take care of the inleaking cooling water.
2. The air pump also is required to carry an extra load because the cooling water leaking into the condenser usually carries much air.
3. The vacuum is reduced because of the overload on the pump handling the water of condensation, and on the air pump. In addition to that the steam side of the cooling surface is soiled by deposits from the cooling water and the cooling action is thereby considerably impaired, especially because of the fact that its cleaning is difficult.
4. The water of condensation is contaminated by the addition of cooling water and becomes unsatisfactory for boiler feeding purposes; if the cooling water is hard, scale is formed, and if it is salty (sea water), carrying over of water by the steam is apt to occur.
5. The determination of steam consumption by measuring the amount of water of condensation becomes unreliable as the apparent steam consumption is higher than the actual one.

There are several ways of testing the watertightness of surface condensers. The simplest way is to start the condenser installation working while the turbine is shut off. If the condenser pump continues to deliver water, that shows that there is a leak. In most cases, however, it is desirable to be able to test the watertightness of the condenser plant without stopping the steam turbine. Most of the methods suggested for this purpose are based on the assumption that as the steam is clean, the water of condensation coming from a perfectly watertight condenser may be considered as distilled water, and any leakage of cooling water into it will cause chemical and physical changes, the magnitude of which may be used for indicating the amount of leak.

One of the chemical properties of cooling water which is often used for discovering leaks in condensers is its contents of dissolved calcium and magnesium salts. The hardness of water may be determined, for example, by the Clark method, which consists in adding to the water being investigated, while well shaken, a solution of soap in alcohol of known strength. A deposit of insoluble calcium and magnesium soaps is then formed and its amount indicates the contents of the salts in the water.

This is a very simple process, but not always sufficiently precise. A more reliable method is that of Prof. C. Blacher, in which the hardness of the water is determined by titration with sodium palmitate. The amount of cooling water leaking into the condenser per hour may be determined from the following formulae:

$$K = Q \cdot \frac{h}{H} \text{ and } D = Q - H$$

Where Q = the amount of gases in the water passing per hour through the condenser pump, including the cooling water which has leaked in; K = the amount of cooling water which leaks in per hour; D = the amount of steam condensed per hour; H = the degree of hardness of the cooling water (one degree of hardness means one milligram of CaO in 100 cm^3 of water), h the degree of hardness of the mixture Q.

For example, the apparent amount of water of condensation per hour of a 15,000 kw. turbine with a load of 5000 kw. amounted to 40 metric tons or 8 kg. (17.6 lb.) per kw-hr. The hardness of the cooling water was 20 deg. while the hardness of the water delivered by the condenser pump was 1.5, hence from the above formula the amount of the leak of cooling water was $40 \times \frac{1.5}{20} = 3\ m^3$. The real consumption of steam of the turbine was, therefore, 37 metric tons or 7.4 kg. per kw-hr.

If sea water is used for cooling in a surface condenser, the leak may be discovered through the difference in specific gravity by means of hygrometers. The German Navy employs such instruments which permit of reading the sea water content in the water of condensation directly in percentages.

The English house, Digby & Diggs, have placed on the market a device for determining the quantity of salt solutions in water by measuring the electrical resistance of the liquid. This method has these disadvantages, first, that correction must

be made for the temperature of the solution, and, second, that errors are apt to occur because of polarization phenomena at the electrodes of the measuring apparatus.

Some such tests ought to be made in well conducted plants at least once a day. (*Die Feststellung von Undichtigkeiten an Oberflächenkondensatoren*, Otte, *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 38, no. 48, p. 393, November 26, 1915, 2 pp. *p.*)

Varia

Pipe Couplings, R. S. Lord

The paper discusses the question of pipe couplings with particular regard to their use on gas lines.

The essentials of a good pipe coupling are tightness, flexibility, allowance of expansion and contraction, strength, and rigidity. The apparent contradiction between the requirements of flexibility and rigidity is due to the fact that while the ability to make bends easily is a very important matter to a pipe line builder, the degree of flexibility must be controlled by something in the joint itself, or by proper anchorage. In the matter of strength, present day demands require a very high standard as in natural gas pipe lines pressures run in some cases up to 1200 or even 1400 lb. Fortunately these extreme pressures are never carried any distance from the well, or for any length of time without natural reduction due to expansion into the large space of a big pipe line.

The fluids to be carried have an important bearing on the requirements of a pipe coupling. Natural gas has no appreciable effects on rubber gaskets used on plain end pipe unless it be saturated with oil or gasoline. Artificial gas is also practically harmless when dry, but the coal distillate known as drip oil and often found in it, is even worse than gasoline in its effect on coupling gaskets.

In the use of cast iron pipe only three classes of joints are common, bell and spiggot, flanged, and machined or universal. The bell joints depend upon cement or a soft metal such as lead for sealing. Cement does not permit of any variation from the alinement given the pipe when laid and this may cause strain sufficient to break the pipe. The weakness of lead lies largely in the fact that when once compressed or forced out of position it lacks any elastic power that would tend to return it to its position. In recent years lead wool has been hammered into bells to form a more solid packing than that made by pouring molten lead and then caulking the face.

The joints in use on wrought iron pipe have until recent years been threaded. The author vigorously opposes the statement often made that a properly laid screw line will not leak. He believes that it will.

The article describes in some detail the following joints: Van Stone, E. C. Converse, H. Sellers McKee, and the Matheson.

As regards rubber packed couplings, the author divides them into two general classes, those intended to be packed by the pressure of fluid carried, and those packed by force applied externally working against the pressure within. The author also describes the Gillespie and the Custer pipe couplings as well as the design placed on the market by the Hammond Coupler Co., in which the outer flange is entirely done away with, the bolts holding themselves on by a hook at the head and a clip at the nut end. The bolts rest directly against the broad band of the ring in semi-circular notches made for the purpose of locating them. The hooks coming behind these rings make the pull as direct against the gasket as it is possible to get it. The strength of the ring is made in the direction of this pull of the bolts so that it cannot be bent between the bolts. The author discusses also the plain end pipe coupling and the gaskets used in that connection. (*The Natural Gas Journal*, vol. 9, no. 12, p. 556, December 1915, 6 pp. *cd.*)

Water Softening by Permutit

Description of the isolated plant of the new Central Y. M. C. A. in Brooklyn, N. Y. An interesting feature of the plant is the Permutit plant for water softening. The water comes from an Artesian well and is very hard having a content of lime and magnesium 270 parts to the million. It was, therefore, quite unsuitable for boiler feed and even for bathing purposes inasmuch as it would not form soap lather to any extent. It did not readily lend itself to the lime-soda method of treatment either. The high content of magnesium salts in the water would require a tremendous excess of lime and soda ash and a time of reaction of from 4 to 6 hours. In addition to that, as the salts formed in the lime soda method of treatment are partially soluble in water at ordinary temperatures, there would always remain in the treated water besides an excess of chemicals a certain hardness expressed as calcium carbonate, and in the boilers this would be precipitated and the result would be a bad scale in the heating coils, heaters, pipe lines, and boilers themselves. Furthermore a huge settling tank of about 3500 cu. ft. would be required for the lime-soda softener.

Instead of that a small compact Permutit plant of about 500 cu. ft. was installed. The filtering medium is an artificial silicate which has the property of absorbing all of the calcium and magnesium salts from the water passing through it and substituting for them its sodium base. When the total amount of zero water for which the plant is designed is realized the filters are restored to their original softening efficiency by introducing a solution of unrefined salt (sodium chloride). This solution is allowed to remain in contact with the Permutit for a period of 10 hours, it is then washed directly into the sewer and the filter is again ready for the next day's run.

The plant installed is capable of handling 60,000 gal. per day of the very hard well water. This capacity is divided between two filters. After 30,000 gal. have been filtered through, each filter is regenerated by passing about 1000 gal. of brine through it. (Model Plant in Brooklyn Y. M. C. A., *The Isolated Plant*, vol. 8, no. 1, p. 3, January 1916, 2 pp., 2 figs. *d.*)

Economic Methods of Preparing Metal Shavings for Packing, R. Philipp

A paper read before the Lower Rhine Section of the Verein deutscher Ingenieure on the economic methods of handling metal shavings with special regard to the best ways of preparing them for packing.

One of the great difficulties in the shipment of metal shavings is that unless they are mixed with a sufficient amount of very fine material, they occupy a volume out of proportion with their weight which naturally increases freight charges, sometimes to a prohibitive extent, or in any case materially reduces the price which a shop can get for its waste metal.

Of late (for about six years) serious efforts have been made to prepare the shavings at the plant for economic shipment. Jones and Lamson of Springfield, U. S. A., have provided on their turret lathes an arrangement for breaking up the shaving as it originates. This device consists of a little bridge over which the shaving has to run; at the end of it the shaving is sharply deflected into another direction and broken thereby. This device did not prove practical.

Another attempt was to arrange the cutting itself in such a manner as to prevent the formation of long shavings. This

may be done by giving the tool a peculiar shape such as spoon shape, which prevents the cutting from coming out in a smooth ribbon, prevents it from twisting, and forces it to run in a plane. This gives the shaving bends which with many kinds of steel make it brittle. This process has only a very limited application.

Another proposal belonging to the same class was to set the cutting edge of the tool at right angles to the axis of rotation. For heavy work and for many kinds of steel this is not adaptable because it increases the power consumption and does not prevent the formation of long, strong shavings. It was attempted to destroy the elasticity of the shavings by annealing and hardening them which would make them brittle, but this process proved to be too expensive.

Attempts to cut the shavings themselves likewise did not prove successful because thin shavings can be cut only with very sharp tools, and unless the tools are quite sharp the shavings begin to bend and clog the machinery. Further, cutting requires rapid and uniform feeding of the shavings which is not always possible, and even if all these difficulties have been overcome, the output even at the high speed of cutting will be quite small.

Another process which is used to a certain extent by briquetting concerns outside of Germany consists in allowing the shavings to get rusted. This makes them somewhat brittle so that they can be broken up in a rolling mill or coal crusher. Before, however, they can be sent to the briquetting presses they must be passed through a screen so as to eliminate large lumps and pieces of shavings which might injure the presses. One of the disadvantages of this process is that the metal, being partly rusted, is of lower quality.

Hammer mills can be also used for this purpose but the disadvantage of such types of mills lies in the fact that the shavings are apt to roll about the rollers sometimes to such an extent that it requires a hammer and chisel to get them away.

The application of scrapers does not entirely eliminate this evil, besides it is necessary for various reasons to make one of the rolls adjustable which complicates the use of scrapers.

The locomotive factory of Henschel & Son in Kassel, Germany, has built for its own use a kind of rolling mill consisting of two geared rollers, a characteristic feature of this construction being that both rollers are of the same diameter and mesh from top outward. At the outer sides of the rollers are located sharp deflectors. One of the advantages of this construction is that it can take care of large bales of shavings because the rolling breaks up the bales. On the other hand, however, this construction did not prevent the shavings from twisting all about the rolls even though the deflector could be made very strong and could be placed quite close to the rigidly held rolls.

The Lauchhammer Company in Reise uses another process, namely, of baling the shavings which must be in this case mixed with a certain amount of thin sheet iron pieces and wire. The baling press consists in this case of a large box with four movable holes. After this box has been filled with shavings by means of a lifting magnet, the cover is mechanically forced on and then first one of the side holes and next two more touching it are gradually forced in. The press consumes about 175 h.p., 25 h.p. for forcing on the cover, 50 h.p. to move the first side hole, and 100 h.p. to force in the other two holes in contact with the first one. Six bales can be made in this way per hour. In order, however, that they should maintain their shape the bottom of the box must be covered with sheet iron or wire; then the shavings come in the middle and the top is again covered with sheet iron or wire. In machine shops this process is, therefore, not applicable since there is no sheet iron or wire waste available in the first place, and in the second place the space required and the cost of operation are prohibitive.

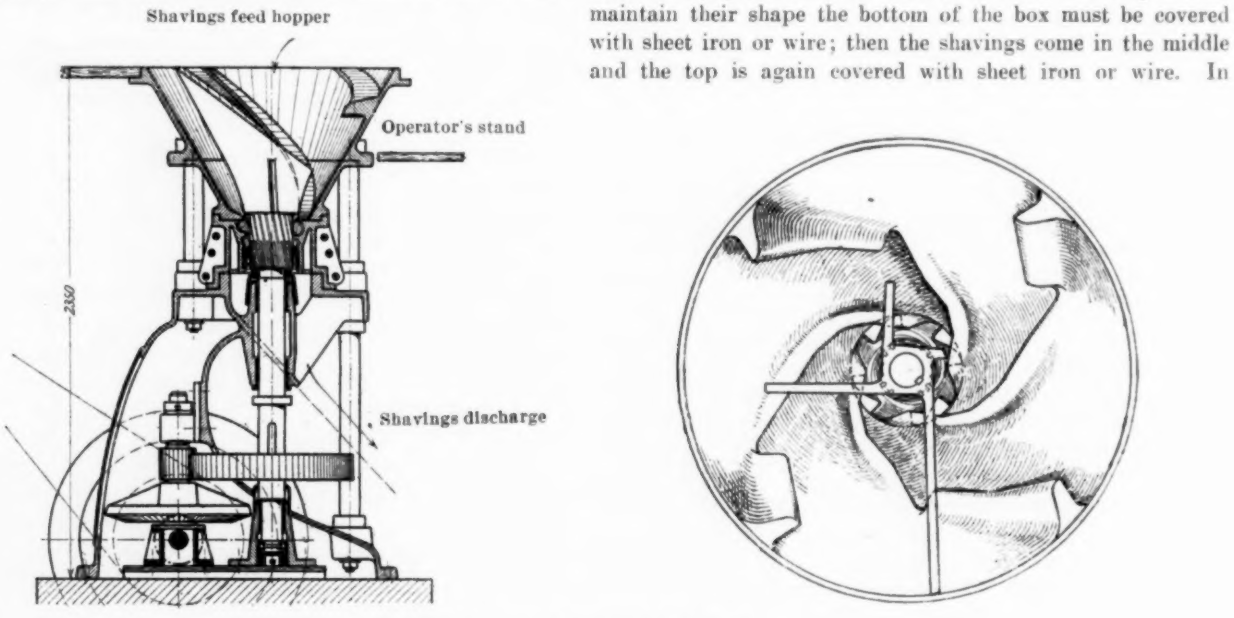

Fig. 8 Metal Shavings Crusher

The locomotive factory of Henschel & Son build the shavings breaker shown in Fig. 8 A, while Fig. B shows the feeding hopper of the same machine. Tough shavings have the undesirable ability of wrapping themselves around the rolls. This property has been made use of here. The roll of peculiar shape rotates in a funnel which is provided with spirally located guides forming as they go downward, channels. Ribs on the roller gradually force the shavings into the passage where they are more and more compressed and shifted outward. By an appropriate formation of the ribs in the funnel and on the roll, the shavings are uniformly distributed through all the channels over the entire cross section of the roll. With say 30 r.p.m. of the roll with 8 ribs in the funnel and 20 on the roll itself, 4800 cuts are made per minute. To this must be added that by being compressed in the channels the shavings are broken to pieces: there is practically no actual cutting which is necessary only in the case of very tough shavings or pieces of wire and sheet metal. Because

of the very low velocity of the rolls which is from 20 to 25 r.p.m. and has at most a diameter of 200 mm. (say 8 in.) there are no violent blows and this reduces the work of the apparatus. The power consumption varies quite materially. It was found that the average power consumption of the larger units for an output of 2500 to 3000 kg. (5500 to 6600 lb. per hr.) was only 13 kw. The largest output obtainable from one engine was 3500 kg. (7700 lb. of manganese copper in 25 minutes) which was obtained with the engine driven by an electric motor rotated at 25 h.p. The cost of breaking up the shavings is approximately 1 mark per ton (say 24c per 2200 lb.). The main elements of this cost are power consumption and wages for bringing the material in and taking it away. The wear of the machine itself does not amount to anything for all practical purposes. (*Wirtschaftliche Behandlung der Eisen- und Metallspäne,* R. Philipp, *Zeits. des Vereines deutscher Ingenieure,* vol. 59, no. 17, p. 962, 3 pp., 3 figs. *dp.*)

Railway Electrification and the Solution of the Smoke Problem in Chicago

The article presents an abstract of the report submitted as a result of an investigation begun four and a half years ago by the Chicago Association of Commerce.

The investigation was at first in charge of Horace E. Burt and after his death in 1913 was conducted by W. F. M. Goss as Chief Engineer of the Committee. The report is quite voluminous (1177 pages), and only the most important conclusions can be here reported.

The Chicago electrification would equal the combined electrifications of the whole world, would involve problems never heretofore met, and would be the first ever undertaken for air betterment where terminals were adequate from an operating viewpoint. At the same time the steam locomotive stands only third among smoke producing services and its elimination would reduce the gaseous pollution of the air only 5 per cent and the solid pollution less than 4 per cent, some of the other worst offenders from the point of view of smoke production being high pressure steam plants, metallurgical and other manufacturing furnaces, and domestic fires.

Smoke regulation in many places erred in confining itself to the visible aspects of smoke, whereas the really harmful factors are invisible gases and the solids of combustion, sulphurous gas and mineral dust in particular.

The researches of the Committee disclosed a significant fact by emphasizing the relatively great importance of the solid constituents of smoke. The cloud effects are of secondary importance as compared with the effects produced by the soot and dust of smoke. The problem of smoke abatement, therefore, is not entirely or largely a problem of suppressing visible smoke, but is one of suppressing the shower of soot, dust, and cinders constantly falling from a smoke polluted atmosphere. Owing to the finely divided state of the solids emitted in the smoke of steam high-pressure stationary power and heating plants, the resulting pollution may be regarded as affecting wide areas since such materials are easily carried by the wind and air currents.

No type has been found except straight electrification which could provide a substitute for steam locomotives. The power requirements of heavy traffic such as is met in and around Chicago are still beyond the gasoline driven engine. The Diesel and oil burning marine engine have the power, but neither type is self-starting, an imperative requirement for switching work. A new Diesel experimental locomotive was examined in Switzerland. Much has been hoped from it, but the inventor himself was doubtful of its success in such heavy yard switching work as would be required here. The storage battery appears to lack power, to be too expensive, and to share with electrification the disadvantage of producing power house smoke. Compressed air and hot water motors were found impractical. Their use is suggested on those sections of the Chicago track which cannot be electrified. Finally electrification itself in Chicago must depend upon the existence and operation of a steam driven electric generating station which would give off enough smoke to counterbalance at least part of the advantages gained by the electrification.

On the whole it seems to be clearly the opinion of the Committee that the results obtained would not warrant the extremely large investment (close to $275,000,000) to abate only a comparatively small part of the visible smoke of the city. It recommends, therefore, the organization of a Pure Air Commission, the business of which would be to eliminate such pollution of air by dust or smoke, not by railroads only but from all sources, including domestic fires, as can be avoided with reasonable expenditure in money and trouble. (*$600,000 Inquiry Finds Electrification Will Not Solve Chicago's Smoke Problem, Engineering Record,* vol. 72, no. 24, December 11, 1915, p. 727, 5 pp., 2 figs. *gd.*)

SELECTED TITLES OF IMPORTANT ENGINEERING ARTICLES

AERONAUTICS

Depreciation and Obsolence in Ice Plants, John E. Starr. Refrigerating World, vol 50, no. 1, Jan. 1916, 1½ pp.

Der Flugelschlag und die Schlagwirkung, Gustav Lilienthal. Zeitschrift für Flugtechnik und Motorluftschiffahrt, Jahrgang 6, Heft 21 u. 22, Nov. 27, 1915, 7¼ pp., 11 figs.
Wing Flapping.

Wärme-und Kälteabwehrmassnahmen beim Bau von Luftschiffhallen, Von C. Friedrich Otto. Zeitschrift für Flugtechnik und Motorluftschiffahrt, Jahrgang 6, Heft 21 u. 22, Nov. 27, 1915, 3¾ pp.
Protection against Heat and Cold in the Construction of Airship Hangars.

AIR MACHINERY

The Mirrlees-LeBlanc "Multijector" Air Pump. Steamship, vol. 27, no. 319, Jan. 1916, 5½ pp., 11 figs.

Some Notes on the Comparative Costs of Compressed Air and Electricity for Use in Mine Stope Haulages, A. E. Middleton. The Transactions of the South African Institute of Electrical Engineers, vol. 6, part 8, Oct. 1915, 4¼ pp.

HYDRAULICS

Bremsversuche an einer neuen schnellaufenden Wasserturbine von Escher Wyss & Cie, Dr. F. Prasil. Schweizerische Bauzeitung, Band 66, Nr. 26, Dec. 25, 1915, 3½ pp.
Brake Tests of a High Speed Water Turbine.

Fortschritte im Bau der Wasserturbinen, (Fortsetzung) Von W. Wagenbach. Zeitschrift des Vereines deutscher Ingenieure, Band 59, Nr. 49, Dec. 4, 1915, 6 pp., 17 figs.
Progress in the Design of Water Turbines

INTERNAL COMBUSTION ENGINES

Die günstigsten Abmessungen raschlaufender Wellen mit Rücksicht auf ihre krirische Drehzahl, Von Heinrich Holzer. Zeitschrift für das gesamte Turbinenwesen, 12 Jahrgang, Heft 32, Nov. 20, 1915, 2¼ pp., 5 figs.
Best Dimensions of Rapidly Rotating Shafts with regard to their Critical Speed.

History and Development of American Water Gas Processes, Owen Evans. The Gas Age, vol. 37, no. 2, Jan. 15, 1916, 9¾ pp., 6 figs.

Hot-Bulb Crude-oil Engines—1, E. M. Rose. Mechanical World, vol. 59, no. 1514, Jan. 7, 1916, 1 p.

Kromhout Marine Oil Engine. Steamship, vol. 27, no. 319, Jan. 1916, 4 pp.

Martin's 2-Cycle Semi-Diesel Engine. Practical Engineer, vol. 20, no. 2, Jan. 15, 1916, 2¼ pp.

Motorer i Seilskibe. Teknisk Ukeblad, 62 Aarg., no. 51, Dec. 17, 1915, ¾ p.
Auxiliary Motors on Sailing Vessels.

A New Method of Bending Plates for Eliminating Riveted Joints in Light Steel-Boat Construction. Shipbuilding and Shipping Record, vol. 6, no. 27, Dec. 30, 1915, 1½ pp., 6 figs.

Oljemotorer Pa Baltiska Utställningen, Halvar Skoglund. Mekanik, 45 Arg., Haft 12, Dec. 8, 1915, 3 pp., 6 figs.
Oil engines at the Baltic Exposition.

Tessé Rotary Cylinder Motor. The Practical Engineer, vol. 53, no. 1506, Jan. 6, 1916, 1 p., 4 figs.

The Werkspoor Marine Diesel Engine, J. Rendell Wilson. International Marine Engineering, vol. 21, no. 1, Jan. 1916, 4 pp., 7 figs.

MACHINE SHOP METHODS AND TOOLS

Brings Out Three Novel Machine Tools. The Iron Trade Review, vol. 57, no. 27, Dec. 30, 1915, 1 p., 3 figs.

Design and Construction of Sprockets, B. D. Pinkney. Machinery, vol. 22, no. 5, Jan. 1916, 4¼ pp., 23 figs.

The Development of Quick Acting Forging Presses—no. 2. A. J. Capron. Canadian Machinery and Manufacturing News, vol. 14, no. 26, Dec. 23, 1915, 1¼ pp., 3 figs.

Entwicklung und Ziele im deutschen Grosswerkzeugmaschinenbau, A. Schmidt. Zeitschrift des Vereines deutscher Ingenieure, Band 59, Nr. 49, Dec. 4, 1915, 3¼ pp. and 6 figs.
Development and Aims of the German Heavy Tool Industry.

History of Machine Tools, Joseph W. Roe. Machinery, vol. 22, no. 5, Jan. 1916, 4½ pp., 5 figs.

Holding Devices For Tapered Work, Albert A. Dowd. Machinery, vol. 22, no. 5, Jan. 1916, 6½ pp., 11 figs.

Lubrication of Bearings and Cylinders, F. L. Fairbanks. The Isolated Plant, vol. 8, no. 1, Jan. 1916, 3 pp.

Making Slush Castings. Machinery, vol. 22, no. 5, Jan. 1916, ¾ p.

A New Form of Worm Gear. Machinery, vol. 7, no. 169, Dec. 23, 1915, ¾ p.

Pilots, Fred Horner. Machinery, vol. 7, no. 169, Dec. 23, 1915, 2¾ pp.

A Practical Discussion of Heat Treatment, W. H. Phillips. Steel and Iron, vol. 50, no. 1, Jan. 1916, 2½ pp.

The Production of Die-Pressed Castings, Edward K. Hammond. Machinery, vol. 22, no. 5, Jan. 1916, 8 pp., 16 figs.

Reckoning Out Weights of Castings, Joseph G. Horner. The Foundry Trade Journal, vol. 17, no. 168, Dec. 1915, 3¾ pp., 5 figs.

Some Observations on Continental Foundry Practice, H. G. Barrett. The Foundry Trade Journal, vol. 17, no. 168, Dec. 1915, 3½ pp., 3 figs.

Straight Keys and Their Strength Values, Percival K. Reed. Machinery, vol. 7, no. 169, Dec. 23, 1915, 1¾ pp.

A Test of Hack Saw Blades. The Metal Industry, vol. 14, no. 1, Jan. 1916, 1 p.

Turning Ivory Billiard Balls, Edward K. Hammond. Machinery, vol. 22, no. 5, Jan. 1916, 2¼ pp., 6 figs.

MATERIALS OF CONSTRUCTION

Beitrag zur Angreifbarkeit von Beton durch Sulfate, A. Sartori. Chemiker-Zeitung, Jahrgang 39, no. 150, Dec. 15, 1915, ¾ p.

The Cause and Effect of "Ghost Lines" in Large Steel Forgings, Prof. J. O. Arnold. The Institution of Mechanical Engineers, no. 9, Dec. 1915, 20 pp., 4 figs.

The Chemical and Mechanical Relations of Iron, Molybdenum and Carbon, Prof. J. O. Arnold. The Institution of Mechanical Engineers, no. 9, Dec. 1915, 23 pp., 11 tables, 2 figs.

The Choice of Steel for Use in Automobile Construction, J. H. S. Dickenson. The Automobile Engineer, vol. 5, no. 85, Dec. 1915, 7 pp., 11 figs.

The Crushing and Tensile Tests of Materials. Bul. no. 8, Kansas City Testing Laboratory, Feb. 1, 1915, 7 pp.

A Development of Practical Substitutes for Platinum and its Alloys, with Special Reference to Alloys of Tungsten and Molybdenum, Frank Alfred Fahrenwald. Bulletin of the American Institute of Mining Engineers, no. 109, Jan. 1916, 148 pp.

The Elastic Strength of Metals, Frank Charles Thompson. Transactions of the Faraday Society, vol. 11, part 1, Oct. 1915, 13½ pp., 7 figs.

Flash and Fire Tests for Lubricating Oils. Steel and Iron, vol. 50, no. 1, Jan. 1916, 1½ pp.

On the Magnetic Transformation of Cementite, Kotaro Honda and Hiromu Takagi. Engineering, vol. 100, no. 2,609, Dec. 31, 1915, 3 pp., 5 figs.

Manilla Rope, F. E. Weise. Railway Review, vol. 57, no. 26, Dec. 25, 1915, 5½ pp., 11 figs.

Methods for the Examination of Bituminous Road Materials. Prévost Hubbard, and Charles S. Reeve. U. S. Dept. of Agriculture Bul. no. 314, Dec. 10, 1915, 43 pp.

Petroleum and Its Products. Bul. no. 9 Kansas City Testing Laboratory, Oct. 1915, 19 pp.

Recrystallization of Cold-Worked Alpha Brass on Annealing, C. H. Mathewson and Arthur Phillips. Bulletin of the American Institute of Mining Engineers, no. 109, Jan. 1916, 50 pp.

In Regard to Rust Prevention. Scale Journal, vol. 2, no. 3, Dec. 25, 1915, ½ p.

Report on the Destructive Action of Sea Water on Concrete and Methods of Guarding Against it, W. Watters Pagon. Monthly Journal of the Engineers Club of Baltimore, vol. 5, no. 6, Jan. 1916, 10 pp.

Semi-Steel, J. E. Hurst. The Foundry Trade Journal, vol. 17, no. 168, Dec. 1915, 4¾ pp., 3 figs.

Specifications and Other Information Concerning Asphalt and Other Materials Used in Paving. Bul. no. 4, Kansas City Testing Laboratory, June 1, 1913, 9 pp.

MEASUREMENTS AND MEASURING APPARATUS

Anwendung des Nonius im Maschinenbau. Von E. Toussaint. Werkstatts Technik, 9 Jahrg., Heft 22, Nov. 15, 1915, 3 pp., 9 figs.

Use of the Nonius in Machine Construction.

Aufzeichnung schnell veränderlicher Vorgänge. Dr.-Ing. Gg. Keinath. Elektrotechnische Zeitschrift, 36 Jahrgang, Heft 48, Dec. 2, 1915, 3 pp., 7 figs.

Recording of Rapidly Varying Phenomena.

The Cochrane Recorder for Measuring Flow over Weirs. Steam, vol. 17, no. 1, Jan. 1916, 1½ pp.

Definitions and Tables of Equivalents of Weights and Measures. Bul. no. 7, Kansas City Testing Laboratory, June 1, 1914, 15 pp.

A New Method for Determining the Specific Heat of Liquids. E. J. Hartung. Transactions of the Faraday Society, vol. 11, Part 1, Oct. 1915, 5 pp., 3 figs.

Nomographic Charts for Conveyor Belt Calculations. Robert E. Haylett. Metallurgical and Chemical Engineering, vol. 14, no. 1, Jan. 1, 1916, ¾ p.

Notes on a Convenient Thermostat for Accurate Specific Gravity Determinations and a Gas Pressure Regulator. K. C. Browning and C. T. Symons. Transactions of the Faraday Society, vol. 11, part 1, Oct. 1915, 4 pp., 2 figs.

Some Sources of Error in Viscosity Measurement. E. C. Bingham, H. I. Schlesinger, and A. B. Coleman. The Journal of the American Chemical Society, vol. 38, no. 1, Jan. 1916, 14 pp.

Über Temperaturmessungen bei Verdampfungsversuchen. Von M. R. Schulz. Zeitschrift für das gesamte Turbinenwesen, 12 Jahrgang, Heft 32, Nov. 20, 1915, 2¾ pp., 5 figs.

Measurements of Temperature in Evaporation Tests.

MECHANICS

Bestimmung der Schallgeschwindigkeit und des Verhältnisses der spezifischen Wärmen der Gase nach der Methode der Kundtschen Staubfiguren. Gustav Schweikert. Annalen der Physik, Band 48, no. 21, Nov. 1915, 74 pp.

Determination of the Velocity of Sound and Ratio of Specific Heats of Gases by the method of Kundt Dust Figures.

An Elementary Account of the Quantum Theory, J. Rice. Transactions of the Faraday Society, vol. 11, part 1, Oct. 1915, 17½ pp.

Helical Springs under Centrifugal Action, John S. Myers. Machinery, vol. 22, no. 5, Jan. 1916, 3¾ pp., 2 figs.

Méthode de calcul de la flèche d'un arbre reposant sur deux tourillons, J. Cabrol. La Lumière Electrique, vol. 37, no. 49, Dec. 18, 1915, 3 pp.

Calculation of the Bending of a Shaft Having Two Bearings.

On the Effect of the Form of the Transverse Section on the Frictional Resistance to the Motion of an Elongated Body Parallel to its Length Through a Fluid, Charles H. Lees. Proceedings of the Royal Society, vol. A 92, no. A 636, Dec. 1, 1915, 14 pp., 7 figs.

MUNITIONS

High Explosive Shell Manufacture. Canadian Machinery, vol. 14, no. 27, Dec. 30, 1915, 7 pp., 18 figs.

High Explosive Shell Manufacture. Canadian Machinery, vol. 15, no. 1, Jan. 6, 1916, 4 pp., 9 figs.

Large Shells: Production Problems and Possibilities.—No. 6, C. T. D. Canadian Machinery and Manufacturing News, vol. 14, no. 26, Dec. 23, 1915, 4½ pp., 7 figs.

Les machines-outils pour l'usinage des obus, F. Hofer. Le Génie Civil, Tome 67, no. 24 and 25, Dec. 11 and 18, 1915, 8½ pp., 18 figs.

Making Cartridge Cases on Bulldozers and Planers, Douglas T. Hamilton. Machinery, vol. 22, no. 5, Jan. 1916, 4¼ pp., 13 figs.

The Manufacture of Shell Forgings. The Engineer, vol. 120, no. 3130, Dec. 24, 1915, ½ p.

Manufacturing Brass Cartridge Cases for 18 Pdr. Shells. Canadian Machinery, vol. 14, no. 27, Dec. 30, 1915, 5¾ pp., 17 figs.

Selbstladepistolen, Hauptmann Polster. Zeitschrift des Vereines deutscher Ingenieure, Band 59, Nr. 49, Dec. 4, 1915, 5¼ pp., 12 figs.

Automatic Small Arms.

RAILROAD ENGINEERING

Heavy Pacific Type Locomotive for the Lackawanna. Railway Age Gazette, 60th year, no. 26, Dec. 24, 1915, 2½ pp., 3 figs.

Powerful Mikado Type of Locomotive for the Missouri, Oklahoma and Gulf Railway. Railway and Locomotive Engineering, vol. 29, no. 1, Jan. 1916, 1 p.

Production of Smoke by the Railways of Chicago. Railway Age Gazette, 60th year, no. 26, Dec. 24, 1915, 3¾ pp.

Railway Engineering in the Northwest—Rotary Snow Plows and Snow Sheds Ready for Winter. Railway and Locomotive Engineering, vol. 29, no. 1, Jan. 1916, 3¼ pp.

The Trackless Train, G. W. Bulley. The Electric Journal, vol. 13, no. 1, Jan. 1916, 4½ pp., 7 figs.

The Upkeep of Railway Wagons. The Engineer, vol. 120, no. 3131, Dec. 31, 1915, 1¾ pp.

Weston Brake Design, H. W. Mellor. Machinery, vol. 7, no. 169, Dec. 23, 1915, 2½ pp., 2 figs.

STEAM ENGINEERING

The Application of High Pressure Exhaust Steam to Manufacturing Purposes, James M. Taggart. Steam, vol. 17, no. 1, Jan. 1916, 4½ pp.

Boiler Corrosion, John B. C. Kershaw. National Engineer, vol. 20, no. 1, Jan. 1916, 3 pp.

Features of Rolling Mill Reversing Engines, W. Trinks. The Blast Furnace and Steel Plant, vol. 50, no. 1, Jan. 1916, 3 pp.

Die Festellung von Undichtigkeiten an Oberflächenkondensatoren. Von Oberingenieur Dipl. Zeitschrift für Dampfkessel und Maschinenbetrieb, Organ für die Dampfkessel-Ueberwachungs-Vereine, Nr. 48 to 38 Jahrgang, Nov. 26, 1915, 2 pp.

Location of Leaks in Surface Condensers.

New Ford Valves. Steam, vol. 16, no. 6, Dec. 1915, 1 p., 2 figs.

Safe Working Pressure of Boilers. Mechanical World, vol. 58, no. 1513, Dec. 31, 1915, 1 p. 2 figs.

Turbine or Engine for Small Capacity Use, J. S. Barstow. Steel and Iron, vol. 50, no. 1, Jan. 1916, 5 pp.

Über die Verwertung der Abwärme von Verbrennungsmaschinen in Turbinen, Wilhelm Gentsch. Zeits. für das gesamte Turbinenwesen, 12 Jahrgang, Heft 34, Dec. 10, 1915, 3¼ pp., 6 figs.

Utilization of Exhaust Heet of Internal Combustion Engines in Turbines.

A Uniform Boiler Code, Thos. E. Durban. Pennsylvania Dept. of Labor and Industry, vol. 2, no. 9, Sept. 1915, 5 pp.

A Uniform Boiler Code, Clarence C. Perry. Pennsylvania Dept. of Labor and Industry, vol. 2, no. 9, Sept. 1915, 5 pp.

VARIA

Automobile Testing, (Extracts from thesis "Automobile Testing" by P. W. Thayer, and J. H. Gammell, H. J. Mayer). The Minnesota Engineer, vol. 24, no. 1, Dec. 1915, 3 pp.

Brass Foundry Ague, Randall Zimmerman. Pennsylvania Dept. of Labor and Industry, vol. 2, no. 9, Sept. 1915, 2 pp.

Details of a Dry Blast Apparatus, John B. Miles. The Iron Trade Review, vol. 58, no. 3, Jan. 20, 1916, 1½ pp.

Efficiency in Track Work, Prof. S. L. Conner. New England Railroad Club, Dec. 14, 1915, 30 pp.

Die Eisenbetonkuppel des Neuen Kirkusgebäudes In Kopenhagen, Prof. M. Foerster. Armieter Beton, Achter Jahrgang, Heft 2, Nov. 1915, 5 pp., 7 figs.

Electro-Plating with Cobalt, Herbert T. Kalmus, and C. H. Harper, and W. L. Savell. Brass World, vol. 11, no. 1, Jan. 1916, 5 pp.

Engineering Colleges and The War, R. Mullineux Walmsley. The Institution of Mechanical Engineers, Dec. 1915, 38 pp.

The Failure and Righting of a Million Bushel Grain Elevator, Alexander Allaire. Proceedings of the American Society of Civil Engineers, vol. 41, no. 10, Dec. 1915, 24 pp., 20 figs.

Fitting Equations to Plotted Points, J. B. Kommers. The Wisconsin Engineer, vol. 20, no. 3, Dec. 1915, 10½ pp., 6 figs.

The Gauging of Storage Tanks, R. L. Ogden. The Journal of Industrial and Engineering Chemistry, vol. 8, no. 1, Jan. 1916, 1½ pp.

The Grading Industries, Edward S. Wiard. Metallurgical and Chemical Engineering, vol. 14, no. 2, Jan. 15, 1916, 5½ pp., 7 figs.

Heavy Timber Construction, P. B. McDonald. Mining and Scientific Press, vol. 3, no. 26, Dec. 25, 1915, 2 pp., 5 figs.

How Can Folders Be More Economically Distributed and Their Efficiency Increased, B. W. Frauenthal. Proceedings of St. Louis Railway Club, vol. 20, no. 8, Dec. 10, 1915, 6 pp.

L'azione del vento sulle costruzioni. Rivista Tecnica delle Ferrovie Italiane, 4th year, vol. 8, no. 5, Nov. 15, 1915, 6 pp., 13 figs.
Action of Wind on Structures.

Manufacturing Factors in Refractory Brick, Robert H. H. Pierce. Steel and Iron, vol. 50, no. 1, Jan. 1916, 2½ pp.

Moderne Cementfabrikanlaeg. Ingenioren, Aarg 24, Nr. 89, Nov. 6, 1915, 14 pp., 29 figs.

Motor Trucks as the Solution of the Marine Freight Terminal Problem, Merrill C. Horine. International Marine Engineering, vol. 21, no. 1, Jan. 1916, 3 pp., 3 figs.

New Central Technical School. Canadian Machinery, vol. 14, no. 27, Dec. 30, 1915, 16 pp.

New Process Developments—The Manufacture of Leather Belting, No. 1, F. H. Small. Canadian Machinery and Manufacturing News, vol., 14, no. 26, Dec. 23, 1915, 1¾ pp.

Notes on Model Experiments, G. S. Baker. Transactions of the North-East Coast Institution of Engineers and Shipbuilders, vol. 32, part 2, Dec. 1915, 31 pp., 6 figs.

Operating Cost of Small Power Plants, Robert Kehoe. *The Isolated Plant*, vol. 8, no. 1, Jan. 1916, 2½ pp.

Papermaking and Its Machinery, no. 9, Pulp Strainers. The Engineer, vol. 120, no. 3128 and 3131, Dec. 10 and 31, 1915, 7 pp., 14 figs.

Parralel Slide Stop Valve. The Mechanical Engineer, vol. 36, no. 935, Dec. 24, 1915, ½ p.

Piles and Pile Driving, Scale Journal, vol. 2, no. 3, Dec. 25, 1915, ¾ p.

A Process of Cold Enameling. Scientific American, vol. 114, no. 2, Jan. 8, 1916, ⅛ p.

Power Plant Machinery, Part 3. The Isolated Plant, vol. 8, no. 1, Jan. 1916, 2 pp.

Problems of Efficient Methods of Domestic Heating. Nature, vol. 96, no. 2409, Dec. 30, 1915, 2 pp.

Die Rohrleitungen für Anlagen zur Tränkung der Schwellen nach Rüping, M. Jgel. 3¼ pp., 5 figs.
Piping for Plants Impregnating Ties by the Rüping Process.

Shortening Operation Time in Automobile Shops for Increased Production, Charles C. Lynde, Steel and Iron, vol. 50, no. 1, Jan. 1916, 7 pp., 10 figs.

Thomas Hawksley Lecture: "The World's Supplies of Fuel and Motive Power," Dugald Clerk. The Institution of Mechanical Engineers, no. 9, Dec., 1915, 34 pp., 5 figs.

Trenching Machinery Used for the Construction of Trenches for Tile Drains, D. L. Yarnell. Farmers' Bul., no. 698, Dec. 28, 1915, 26 pp.

Modern Fire Exit Facilities, Giles P. Greene. Safety Engineering, vol. 30, no. 6, Dec. 1915, 8 pp., 9 figs.

Electric Propulsion on a Merchant Vessel. International Marine Engineering, vol. 21, no. 1, Jan. 1916, 2¾ pp., 4 figs.

Die elektro-automatischen Thetis-Pumpwerke der Stadt Mülhausen i. Els., A. Schmidt. 3½ pp., 7 figs.
An Electro-Automatic Pumping Plant of the City of Mülhausen, Alsace.

The Geared Turbine and the Turbo-Electric Systems of Marine Propulsion, John H. Macalpine. International Marine Engineering, vol. 21, no. 1, Jan. 1916, 4¾ pp., 2 figs.

Pipe Couplings, R. S. Lord. The Natural Gas Journal, vol. 9, no. 12, Dec. 1915, 6 pp.

Sicherheitsvorkehrungen bei Hochofenschrägaufzügen, Rudolf Brennecke. Stahl und Eisen, Zeitschrift für das deutsche Eisenhüttenwesen, 35 Jahrgang, Nr. 48, Dec. 2, 1915, 12 pp., 20 figs.
Safety Devices on Blast Furnace Hoists.

Steam-Jet Refrigeration, J. C. Bertsch. Refrigerating World, vol. 50, no. 1, Jan. 1916, 5 pp.